SHORT-RUN ECONOMIC ANALYSIS
OF
NITROFEN

United States Department of Agriculture
Economics and Statistics Service
and
United States Environmental Protection Agency
Benefits and Field Studies Division
and State Land Grant Universities

Washington, D.C. February 1981

946699

CONTENTS

SUMMARY

If nitrofen is suspended, increased production costs and reduced quantity/quality of outputs would reduce short term income for impacted growers (Table 1). The loss of income for nitrofen users was estimated to range from $41.0 to $105.6 million: $34.2 to $98.8 million for vegetable crops; $5.8 million for ornamentals; and $1.0 million for non-cropland, pine seedling nurseries, and sugarbeets. Non-users of nitrofen that grow broccoli, brussels sprouts, cabbage, carrots, cauliflower and celery were estimated to have a $40.3 to $63.2 million gain in income due to short run price increases attributed to supply shortfalls; non-impacted growers for other sites may also experience windfall gains, but data were not available for such estimates.

Approximately 291,800 acres are currently treated with 1.27 to 1.37 million pounds a.i. nitrofen (Table 1). Base acre treatments and nitrofen usage by different site classes are as follows:

	Base Acres Treated	Percent	Pounds A.I. Applied	Percent
vegetable crops	277,199	95.0	1,214,439 to 1,305,901	95.2 to 95.5
ornamentals	6,864	2.4	28,720	2.3 to 2.1
other use sites	7,702	2.6	31,832 to 32,540	2.5 to 2.4
total	291,765	100.0	1,274,991 to 1,367,161	100.0

Nitrofen use varies considerably by different vegetable crops. Although nitrofen is only used on about 14 percent of the U.S. brussels sprouts acreage, the base acres treated varies from 35.0 to 49.4 percent for cabbage, carrots, garlic, and onions (Table 1). At least 75 percent of the broccoli, cauliflower, celery, horseradish, parsley and taro/daikon acreage is treated with nitrofen.

If nitrofen is suspended, the short term income of the negatively impacted vegetable growers would decline from $34.2 to $98.8 million (Table 1). Short term windfall income gains ranging from $40.3 to $63.2 million would be received by non-impacted growers that benefit from commodity price increases attributed to supply shortfalls. It should be noted that data availability problems limited the windfall income gain estimates to only broccoli, brussels sprouts, cabbage, carrots, cauliflower, and celery.

Vegetable growers using nitrofen that are expected to have the largest aggregate income losses include: cauliflower (upper limit of $31.2 million); onions (upper limit of $22.1 million); broccoli (upper limit of $15.4 million); and celery (upper limit of $12.2 million) (Table 1). Individual sites that would be expected to have the largest per acre income losses are: parsley (upper limit of $2,160); brussels sprouts (upper limit of $991); and cauliflower (upper limit of $867).

Consumer price impacts at the retail level are expected to be most strongly affected by short run reductions in outputs supplied to the retail markets. Brussels sprouts, cabbage, carrots, garlic, horseradish,

nd onions were estimated to have 0 to) percent reductions in U.S. utput; where estimates could be derive retail price increases between and $.02 per pound are expected (Tabl 1). Broccoli, cauliflower, elery, and taro/daikon were estimated › have domestic output reductions anging from 11 to 15 percent; where es :mates could be derived, ssociated retail price increases range‹ from $.02 to $.04 per pound. arsley output reductions ranged from 2' to 25 percent; retail price ncreases could not be estimated, but m· be quite large.

Nitrofen use on ornamentals is gen :ally quite limited. Although 40 ercent of the U.S. stock acreage is tr‹ ıted, only 7.7 to 12.1 percent of he U.S. acreage for different nitrofen ›rnamental use sites are impacted Table 1). If nitrofen is suspended, t! : short term reduction of mpacted ornamental growers' income wou: l be about $5.8 million.

The largest economic impact would : $5.2 million for the increased stablishment costs of ornamental groun‹ covers. Other ornamental sites ould have short term income losses of : ı10,000 or less. Ornamental ites that are expected to have the lar; :t per acre income losses are ırnations (upper limit of $5,939) and ‹ .rysanthemums (upper limit of 2,495).

Consumer price and quantity/qualit: impacts for these ornamentals :e expected to be negligible.

Nitrofen usage on all other sites limited to about 32,000 pounds .i. applied to 7,700 acres. Although : .3 percent of the pine seedling ırsery acreage in Georgia, North Carol: a, and South Carolina is

treated; less than one percent of the U.S. sugarbeet and non-cropland acreage is impacted (Table 1).

If nitrofen use is suspended, the total short term income reductions for these three sites would range from \$994,000 to \$999,000. Income losses by site are as follows: sugarbeets (\$865,000; \$112 to \$132 per acre); pine seedling nurseries (\$129,000 to \$134,000; \$637 to \$661 per acre); and non-cropland (negligible; no more than \$7 per acre).

For these use sites, price and output impacts upon final consumers are expected to be negligible.

Table 1. Overall Summary of the Short-Run Economic Impacts of a Nitrofen Suspension

Site	Pounds A.I. Applied	Extent of Use: Acres Treated	Extent of Use: Percent of U.S. Acres	Alternative Controls	Type	Producer Income Loss (Gain): Million Dollars	Producer Income Loss (Gain): Dollars Per Acre	Consumer Economic Impact
Vegetable Crops								
broccoli	396,000	66,000	91.9	DCPA + CDEC	users	4.009 to 15.417	61 to 234	11% reduction in
				trifluralin + DCPA				quantity supplied;
				trifluralin + CDEC	non-users	(1.892) to (.946)	(324) to (162)	price increase of
				mechanical cultivation				$.02 to $.04 per
				hand hoeing	total	2.117 to 14.471	29 to 201	pound.
brussels sprouts	2,440	813	14.2	trifluralin + DCPA	users	.726 to .806	893 to 991	5% reduction in
				CDEC + DCPA				quantity supplied;
				DCPA	non-users	(1.415) to (.711)	(288) to (145)	price increase of
				mechanical cultivation				$.01 to $.02 per
				hand hoeing	total	(.689) to .095	(120) to 17	pound.
cabbage	91,462 to 182,924	45,731	49.4	DCPA	users	(.695)to 5.852	(15) to 128	9% reduction in
				trifluralin				quality supplied;
				CDEC	non-users	(28.802) to (18.255)	(498) to (316)	price increase of
				bensulide + DCPA				$.01 to $.02 per
				mechanical cultivation	total	(29.496) to (12.403)	(120) to (285)	pound.
				hand hoeing				

Table 1 (continued). Overall Summary of the Short-Run Economic Impacts of a Nitrofen Suspension

Site	Pounds A.I. Applied	Extent of Use: Acres Treated	Extent of Use: Percent of U.S. Acres	Alternative Controls	Type	Producer Income Loss (Gain): Million Dollars	Producer Income Loss (Gain): Dollars Per Acre	Consumer Economic Impact
Vegetable Crops								
carrots	185,500	31,950	43.3	trifluralin + linuron	users	1.636 to 4.945	51 to 155	5% decline in quantit
				linuron				supplied; price
				linuron + mineral spirits	non-users	(7.889) to (3.944)	(188) to (94)	increase of less than
				linuron + paraquat				$.01 per pound.
				mechanical cultivation	total	(6.253) to 1.000	(85) to 14	
				hand hoeing				
cauliflower	143,872	35,968	86.4	trifluralin	users	(11.357) to 31.171	(316) to 867	15% decline in quanti
				DCPA + sulfallate				supplied; price
				DCPA	non-users	(8.421) to (1.682)	(1,490) to (298)	increases expected, b
				mechanical cultivation				were not quantified.
				hand hoeing	total	(19.777) to 29.489	(475) to 709	
celery	128,867	28,725	79.6	prometryne	users	12.151	423	11.2% reduction in
				prometryne + chloroxuron				quantity supplied;
				prometryne + chloroxuron + mineral spirits	non-users	(14.762)	(1953)	price increase of $.0
								per pound.
				chloroxuron	total	(2.611)	(72)	
				trifluralin				
				linuron				
				mechanical cultivation				
				hand weeding				

Table 1 (continued). Overall Summary of the Short-Run Economic Impacts of a Nitrofen Suspension

Site	Pounds A.I. Applied	Extent of Use: Acres Treated	Extent of Use: Percent of U.S. Acres	Alternative Controls	Type	Producer Income Loss (Gain): Million Dollars	Producer Income Loss (Gain): Dollars Per Acre	Consumer Economic Impact
Vegetable Crops								
garlic	17,544	4,386 (California)	35.0 (California)	bromoxynil hand weeding	users	1.298	296	3.5% decline in Californian quantity supplied; price impacts were not assessed
horseradish	7,500	1,750	79.5	DCPA mech. cultivation hand weeding	users	.275 to .298	157 to 170	No change in quantity supplied; price impacts are expected to be negligible.
kale, collards and mustard greens	data not available			trifluralin DCPA mech. cultivation hand weeding	users	not available	85 to 140	Quantity and price impacts expected to be limited to Hawaii; magnitudes of impact could not be assessed.
onions	228,654	58,726	47.6	CDAA + chloropropham bensulide + DCPA DCPA + sulfuric acid + chloroxuron DCPA + dinoseb + chloroxuron DCPA + sulfuric acid DCPA + chloroxuron sulfuric acid mechanical cultivation hand hoeing	users	21.480 to 22.070	366 to 376	7% reduction in quantity supplied; price increases are expected, but were not quantified.

Table 1 (continued). Overall Summary of the Short-Run Economic Impacts of a Nitrofen Suspension

Site	Pounds A.I. Applied	Extent of Use Acres Treated	Percent of U.S. Acres	Alternative Controls	Type	Producer Income Loss (Gain) Million Dollars	Producer Income Loss (Gain) Dollars Per Acre	Consumer Economic Impact
Vegetable Crops								
parsley	10,600	2,650	100.0	petroleum distillate linuron mech. cultivation hand weeding	users	4.45 to 4.51	1,398 to 2,160 2/	20-25% reduction in quanity supplied; price impacts were not assessed, but could be quite large.
taro and daikon	2,000	500	80.8 (Hawaii)	mech. cultivation hand hoeing	users	.210 to .236	419 to 471	12% decline in Hawaiian quantity supplied; price impacts were not assessed.
total	1,214,439 to 1,305,901	277,199	—	—	users non-users 1/	34.183 to 98.754 (63.181) to (40.300)	—	—

Table 1 (continued). Overall Summary of the Short-Run Economic Impacts of a Nitrofen Suspension

Site	Pounds A.I. Applied	Extent of Use		Alternative Controls	Producer Income Loss (Gain)			Consumer Economic Impact
		Acres Treated	Percent of U.S. Acres		Type	Million Dollars	Dollars Per Acre	
Ornamentals								
carnations	276	69	12.1	hand weeding	users	.389 to .410	5,639 to 5,939	.9% decline in quantity supplied; price impacts are expected to be negligible.
chrysanthemums	108	36	7.7	hand weeding	users	.063 to .090	1,755 to 2,495	14% of higher quality Californian blooms will fall into smaller sized categories; price impacts are expected to negligible.
ground covers	26,360	6,290	data not available	oryzalin napropamide mech. cultivation hand hoeing	users	5.204	827	impacts are expected to be negligible.

Table 1 (continued). Overall Summary of the Short-Run Economic Impacts of a Nitrofen Suspension

Site	Pounds A.I. Applied	Extent of Use: Acres Treated	Extent of Use: Percent of U.S. Acres	Alternative Controls	Producer Income Loss (Gain): Type	Producer Income Loss (Gain): Million Dollars	Producer Income Loss (Gain): Dollars Per Acre	Consumer Economic Impact
Ornamentals								
roses-field	656	164	data not available	trifluralin oxidiazon mech. cultivation hand hoeing	users	.009	54	no change in quantity supplied; price impacts are not expected.
roses - greenhouse	200	25	4.6 to 5.3	oxadiazon hand weeding	users	.003 to .004	105 to 163	no change in quantity supplied; price increases are not expected.
stock	1,120	280	40	trifluralin mech. cultivation hand hoeing	users	.133	476	impacts are expected to be negligible.
total	28,720	6,864	—	—	users	5.801 to 5.850		

Table 1 (continued). Overall Summary of the Short-Run Economic Impacts of a Nitrofen Suspension

	Extent of Use					Producer Income Loss (Gain)		Consumer Economic Impact
Site	Pounds A.I. Applied	Acres Treated	Percent of U.S. Acres	Alternative Controls	Type	Million Dollars	Dollars Per Acre	
Other Use Sites								
non-cropland	data not available; usage is negligible			atrazine dicamba + 2,4-D diuron glyphosphate others	users	not available	6.88 to (31.65)	none expected.
pine seedling nurseries	1,832 to 2,540	202	21.3 (Georgia, N. Carolina, S. Carolina)	petroleum distillate + oxyfluorfen petroleum distillate hand weeding	users	.129 to .134	637 to 661	impacts are expected to be negligible.
sugarbeets	30,000	7,500 (California)	.6	chloropropham desmedipham + phenmedipham clycloate mech. cultivation hand weeding	users	.865	112 to 132 2/	less than a .01% reduction in quantity supplied; price impacts are not expected.
total	31,832 to 32,540	7,702	—	—	users	.994 to .999	—	—
Total - All sites	1,274,991 to 1,367,161	291,765	—	—	users nonusers 1/	40.978 to 105.603 (63.181) to (40.300)	—	—

1/ Non-user income impact analyses were limited to broccoli, brussels sprouts, cabbage, carrots, cauliflower, and celery. Other nitrofen use sites with commodity market price increases would also have some offsetting windfall gains to non-users, but data were not readily available for such assessments.

2/ The range in income impacts considers variation by state/region or by alternative controls.

INTRODUCTION

Nitrofen (TOK®) is a diphenyl ether compound manufactured by Rohm and Haas Company as a selective pre- or postemergence herbicide. Formulated as either a 50 WP or an E 25, nitrofen is used as a weed control in several vegetable crops; ornamentals; and other use sites as non-cropland, pine seedling nurseries, and sugarbeets. For some use sites, a suspension of nitrofen would have large economic impacts of reducing crop output/quality levels and/or increasing production costs because of less effective herbicides and non-chemical alternatives. However, in other cases, effective substitutes are available for some sites in some geographical areas; hence, large economic impacts would not be expected for these situations.

This report primarily examines the short-run implications of a possible nitrofen suspension. Qualitative estimates of the longer-run ramifications of a cancellation are provided whenever possible.

SCOPE

The short-run economic impacts of a possible suspension of nitrofen site registrations are the primary objectives of this study. The nitrofen use sites that were analyzed include: broccoli, brussels sprouts, cabbage, carrots, cauliflower, celery, garlic, kale/collards/mustard greeens, onions, parsley, taro/daikon, carnations, chrysanthemums, ground covers, roses (field and greenhouse), stock, non-cropland, pine seedling nurseries, and sugarbeets.

The economic analyses focus on the short-run changes in growers' income that would result from a potential suspension. When appropriate data and rationales existed, income distributional effects between users and non-users were evaluated for the following sites: broccoli, brussels sprouts, cabbage, carrots, cauliflower and celery. Consumer, macroeconomic, and social/community impacts were primarily limited to qualitative assessments.

The economic impact estimates were derived by the use of partial budgeting techniques. Information on acres treated with nitrofen, alternative weed control input requirements, and comparative performance evaluations (i.e. output and quality changes) between nitrofen and alternatives were provided by the USDA/State biologists; EPA biologists provided the team with information on registered controls, use practices, and use limitations by site. Crop acreage, production, and commodity prices were based mostly on 1977-79 data.

Economic estimates for the long-run were limited to qualitative assesments since information on longer term producer and market adjustments were not readily available.

SUMMARY OF PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON BROCCOLI

A. USE: Nitrofen use on broccoli

B. MAJOR PESTS CONTROLLED:

annual bluegrass	lambsquarters	nettle	shepherdspurse
crabgrass	malva	pigweed	spergularia
goosefoot	nightshade	purslane	

C. ALTERNATIVES:

Major registered chemicals: DCPA, CDEC, and trifluralin

Non-chemical controls: Mechanical cultivation and hand hoeing.

Comparative efficacy/performance: Use of alternative herbicides would reduce yields by an estimated 10 to 15% on the impacted acreage.

Comparative costs:

Nitrofen Program Cost/Acre ($)	Alternative Program Cost/Acre ($)	Difference in Cost/Acre ($)
268.57 - 349.14	436.52 - 537.43	167.95 - 188.29

Nitrofen program includes use of nitrofen in sequence with DCPA, CDEC, or trifluralin, along with 5 mechanical cultivations and 1 hand hoeing. Alternative programs include use of 2 herbicides, such as DCPA, CDEC, or trifluralin. Alternative programs also include greater seeding rates and additional mechanical cultivations and hand hoeings.

D. EXTENT OF USE:

Acres Treated	% of U.S. Broccoli Acreage	Quantity of Nitrofen Used Annually (lb. a.i.)
66,000	93	396,000

Nearly all of the treated acreage is located in California.

E. ECONOMIC IMPACTS:

User: In the short run, the estimated 1,100 growers currently using nitrofen on broccoli would incur annual revenue losses ranging from about $4 to $15.4 million.

Increase in annual production costs ($000):	$11,612.2 to $13,568.6
Change in annual revenue ($000):	-1,848.8 to +7,602.9
Net economic loss ($000):	$4,009.3 to $15,417.4

The short run output reduction due to yield losses on the impacted acreage would increase grower prices by an estimated $1.95 to $3.90 per cwt., providing non-impacted growers with an increase in annual revenues of about $.9 to $1.9 million.

In the longer term, increased broccoli production in nonimpacted areas could reduce market prices and impacted growers' income. Some of the impacted growers would be expected to reallocate their land to other crops less affected by a nitrofen suspension

Market/Consumer: The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of broccoli by about 637,960 cwt, about 11 percent of current industry output. Retail prices would be expected to rise by about 2 to 4 cents per pounds. In the longer run, higher grower prices would stimulate new and expanded production which would increase the supply of broccoli and reduce the initial impact on retail prices.

F. SOCIAL/COMMUNITY IMPACTS: Alternative weed control programs may require additional field labor. The increased demand for field labor may bid up wages and in some cases cause shortages of field labor.

The reallocation of land to other crops may lead to an increased demand for new farm equipment and other factors of production.

Short run reductions in broccoli output may cause some local processors to operate at a less than optimum level of output. In some cases, processors may need to discover out more distant sources of supply or reinvest in new machinery capable of processing alternative crops.

G. LIMITATIONS OF ANALYSIS: Estimates of comparative efficacy of nitrofen and alternative herbicides were based on the experience of weed science specialists and not on field data. Production budget information and up-to-date estimates on price elasticity of demand were unavailable.

H. PRINCIPAL ANALYST AND DATE:

Allen Scheid
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

January 1981

Preliminary Benefit Analysis of Nitrofen Use on Broccoli

Current Use Analysis

EPA Registrations of Nitrofen and Alternatives

Nitrofen is a selective herbicide registered for use on broccoli for the control of a variety of weeds including: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, and spergularia (EPA, 1980). Nitrofen is applied to broccoli at preemergence, usually in combination with other herbicides such as DCPA, CDEC, or trifluralin. On about half of the treated acreage, an additional application of nitrofen is made at postemergence (USDA/EPA/States, 1980). Although available in an emulsifiable concentrate formulation, nitrofen is usually applied to broccoli in the wettable powder form (50 percent active ingredient). The label rate for nitrofen (in both formulations) is 3 to 6 pounds active ingredient per acre (EPA, 1980).

The major alternative herbicides registered for use on broccoli at preemergence are DCPA, CDEC, and trifluralin. No alternative herbicides are available for use on broccoli at postemergence (EPA, 1980; Rowe and Albertson, 1980).

Extent of Nitrofen Use

Broccoli represents the most important use site for nitrofen, both in terms of annual acreage treated and pounds of active ingredient used. Of approximately 71,000 acres of broccoli currently grown in the United States (1977-79 average), about 66,000 acres (93 percent) are treated with nitrofen (USDA/EPA/States, 1980). A total of about 396,000 pounds active ingredient of nitrofen are used on broccoli each year. Nearly all of the treated acreage is located in the state of California (USDA/EPA/States, 1980).

There are an estimated 1,100 farms using nitrofen on broccoli. The average farm size is 60 acres (USDA/EPA/States, 1980).

Farm Impacts

Production Cost Changes

The typical nitrofen weed control program for brocolli would include a preemergence application of nitrofen, usually in combination with other herbicides. On about 75 percent of the treated acreage (49,500 acres), nitrofen would be used in sequence with DCPA. About 15 percent of the acreage (9,900 acres) would be treated with nitrofen and CDEC and about 10 percent of the acreage (6,600 acres) would be treated with nitrofen and trifluralin (USDA/EPA/States, 1980). Approximately 50 percent of the total treated acreage would also receive an additional application of nitrofen at postemergence.

The cost of these various nitrofen treatments would range from about $64 to $119 per acre (Table 1). In addition to herbicide treatments, the nitrofen weed control program would usually include five mechanical cultivations at a cost of $10-$12 per acre per time and one hand hoeing operation per season at a cost of $45-$60 per acre (USDA/EPA/States, 1980).

If nitrofen use on broccoli were cancelled, growers would likely substitute alternative herbicides for nitrofen at preemergence. The principal alternative herbicide programs expected to be used include: DCPA and CDEC (on about 70 percent of the impacted acreage), trifluralin and DCPA (on about 20 percent of the impacted acreage), and trifluralin and CDEC (on about 10 percent of the impacted acreage). The herbicide and application costs of these alternative programs range from about $49 to $83 per acre (Table 2). On the average (for the total 66,000 impacted acres), the use of alternative herbicides would reduce herbicide treatment costs by about $5 to $17 per acre.

The use of alternative herbicide combinations would provide less effective weed control than herbicide treatments using nitrofen. In order to compensate for the reduced effectiveness of alternative treatments, growers would typically increase the number of mechanical cultivations by 2 per season and the number of hand hoeing operations by 1 per season (USDA/EPA/States, 1980). Along with these additional field operations, the use of alternative herbicides would usually require growers to increase their seeding rate by about 5 ounces of seed per acre in order to compete with the increased weed population.

Table 1. Current Herbicide and Application Costs Per Acre for Nitrofen Weed Control Programs on California Broccoli

Weed Control Program	Timing	Application Rate (lb. of a.i./acre)	Cost/Lb. of A.I. ($)	Application Cost/Acre ($)	Herbicide and Application Cost/Acre ($)	Number of Acres Treated
DCPA	Preemergence	3-6	5.27	8.00	23.81-39.62	
+						
Nitrofen	Preemergence	4	7.94	8.00	39.76	
	Total				63.57-79.38	24,750
Nitrofen 1/	Postemergence	4	7.94	8.00	39.76	
	Total				103.33-119.14	24,750
CDEC	Preplant Incorporated	4	5.00	17.00	37.00	
+						
Nitrofen	Preemergence	4	7.94	8.00	39.76	
	Total				76.76	4,950
Nitrofen 1/	Postemergence	4	7.94	8.00	39.76	
	Total				116.52	4,950
Trifluralin	Preplant Incorporated	5	8.05	17.00	21.02	
+						
Nitrofen	Preemergence	4.0	7.94	8.00	39.76	
	Total				60.78	3,300
Nitrofen 1/	Postemergence	4.0	7.94	8.00	39.76	
	Total			Total	100.54	3,300

1/ 50% of treated acreage receives an additional treatement of nitrofen at postemergence.

Table 2. Current Herbicide and Application Cost Per Acre for Nitrofen Alternative Weed Control Programs on California Broccoli

Weed Control Program	Timing	Application Rate (lb. of a.i./acre)	Cost/lb. of A.I. ($)	Application Cost/Acre ($)	Herbicide and Application Cost/ Acre ($)	Number of Acres Treated
DCPA	Preemergence	9.0	5.27	8.00	55.43	
+						
CDEC	Preemergence	4.0	5.00	8.00	28.00	
	Total				83.43	46,200
Trifluralin	Preplant Incorporation	.5	8.05	17.00	21.02	
+						
DCPA	Preemergence	9.0	5.27	8.00	55.43	
	Total				76.45	13,200
Trifluralin	Preplant Incorporation	.5	8.05	17.00	21.02	
+						
CDEC	Preemergence	4.0	5.00	8.00	28.00	
	Total				49.02	6,600

Sources: USDA/EPA/States, 1980.

The use of these additional field operations and increased seeding rates would increase production costs by about $250 to $314 per acre (Table 3).

The net increase in production costs would be about $243.40 to $295.60 per acre (production cost increases of $250 to $314 less the reduced price of herbicide treatments of about $6.60 to $18.40 per acre). Based on 1980 budget estimates for broccoli growers in the Imperial Valley of California (University of California, 1980), the net increase in total production costs would represent an increase of about 8 to 10 percent on the impacted acreage.

For the average grower with 60 acres of broccoli, the use of alternative herbicides would increase annual production costs by about $14,600 to $17,740. The use of alternative weed control on all of the impacted acreage (66,000 acres) would increase annual short term production costs by about $11.6 to $13.6 million (Table 4).

Yield and Revenue Impacts

In addition to increased production costs, broccoli growers using alternative herbicides would also incur yield losses on the treated acreage. The use of DCPA and CDEC would reduce yields by an estimated 10 percent and the use of trifluralin + DCPA or trifluralin + CDEC would reduce yields by about 15 percent (USDA/EPA/States, 1980). The use of these herbicides on the impacted acreage would reduce broccoli ouput by about 637,960 cwt (Table 5), a reduction of nearly 11 percent in the current U.S. annual production.

Table 3. Estimated Impact of a Nitrofen Suspension on Costs for Seeding, Mechanical Cultivations, and Hand Hoeings of California Broccoli (1980)

	With Nitrofen ($)	Without Nitrofen ($)	Change in Cost ($)
Seeding Operations 1/	110	160	50
Mechanical Cultivations 2/	50-60	70-84	20-24
Hand Hoeing 3/	45-60	157.50-210.00	112.50-150.00
Total	205-230	387.50-454.00	182.50-224.00

1/ With nitrofen, precision planting requires 11 oz. of seed/acre at $160/lb. Without nitrofen, seeding rate is increased to 16 oz./acre at $160/lb..

2/ With nitrofen, 5 mechanical cultivations per season at $10-12/acre/time. Without nitrofen, 7 mechanical cultivations at $10-12/acre/time.

3/ With nitrofen, 1 hand hoeing per season requires 6-8 hrs. of labor/acre at $7.50/hr.
Without nitrofen, 1 hand hoeing (6-8 hrs.) and 1 hand hoeing (15-20 hrs.) at $7.50/hr.

Sources: USDA/EPA/States, 1980.

Table 4. Preharvest Costs for California Broccoli, with and without Nitrofen

	With Nitrofen ($000)	With Alternative Herbicide ($000)	Change in Cost ($000)
Herbicide + Application Cost 1/	5,619.9 to 6,402.5	5,187.1	- 432.8 to -1,215.4
Seeding Operations 2/	7,260	10,560	+ 3,300
Mechanical Cultivation 3/	3,300 to 3,960	4,620 to 5,544	+ 1,320 to +1,584
Hand Hoeing 4/	2,970 to 3,960	10,395 to 13,860	+ 7,425 to +9,900
Total	19,149.9 to 21,582.5	30,762.1 to 35,151.1	+11,612.2 to 13,568.6

1/ See Tables 1 and 2 for costs per acre and number of acres treated.
2/ See Table 3, note 1.
3/ See Table 3, note 2.
4/ See Table 3, note 3.

Table 5. Annual Yield Losses Resulting from a Nitrofen Cancellation on California Broccoli

Herbicide Treatment	Expected Number of Acres Treated	Weighted Average Yield/Acre (1977-79) (cwt)	Expected Yield Reduction/Acre (cwt)	Total Expected Yield Reduction (cwt)
DCPA and CDEC	46,200	83	8.3 1/	383,460
Trifluralin and DCPA	13,200	83	12.5 2/	165,000
Trifluralin and CDEC	6,600	83	12.5 2/	82,500
Total	66,000			630,960

1/ Assuming 10% yield reduction
2/ Assuming 15% yield reduction

Sources: USDA, Vegetables 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

The impact of this short run reduction of output on market prices may be estimated through an analysis of price elasticity of demand (assuming that the supply curve is perfectly inelastic in the short run).

Although specific estimates of price elasticity for fresh and processed broccoli are currently unavailable, past studies of demand for farm products suggest that the demand for most vegetables at the farm level is relatively inelastic (Western Extension Marketing Committee, 1967). Studies of demand for vegetable crops such as cabbage, carrots, celery, tomatoes, and peppers have provided estimates of price elasticity at the farm level ranging from -.45 to -1.03 (Brandow, 1961; Waugh, 1964; Shafer, 1965).

The relative inelasticity of demand for broccoli and other vegetables may be explained by the fact that they lack good substitutes and their purchase represents a small part of the consumer's overall budget. Consumers thus tend to respond to reductions in supply by bidding up the market price at a rate that is higher than the rate of output reduction.

In order to estimate the impact that reduced output (on the affected acreage) would have on grower revenue, this analysis has assumed that the farm level elasticity of demand for both fresh and processed broccoli falls into the range of -.5 and -1.0. Under this assumption, the estimated yield reduction (637,500 cwt.) on the affected acreage would cause grower prices to increase by about $1.95 to $3.90 per cwt (Table 6).

Table 6. Estimated Change in Grower Prices Resulting from a Reduction in Broccoli Production

Elasticity 1/	Broccoli Production 2/	Reduced Broccoli Production 3/	Industry Price/Cwt 4/	Expected Price Change/Cwt 5/
(E)	(Q) cwt	(ΔQ) cwt	(P) $	(ΔP) $
- .5	5,798,000	630,960	17.91	+ 3.90
- 1.0	5,798,000	630,960	17.91	+ 1.95

1/ Elasticity is assumed to range between -.5 and -1.0, based on past studies of demand for vegetables at the farm level.
2/ 1977-79 average for U.S.
3/ Output reduction resulting from 10-15% yield reduction on affected acreage (Table 5).
4/ 1977-79 weighted average price for U.S.

5/ Calculated from the equation: Elasticity of Demand = $\dfrac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$

Sources: USDA, Vegetables 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

An increase of $3.90 per cwt in the market price (assuming price elasticity at about -.5) would be sufficiently high to offset revenue losses due to reduced production on the affected acreage. The revenue of the impacted growers would increase by an estimated $7.6 million per year in the short run (Table 7). If market prices rose by only $1.95 per cwt (assuming a price elasticity of about -1.0), affected growers would incur a loss of revenue estimated at $1.8 million per year (Table 7).

The short term net economic impact (in terms of changes in both production cost and revenues) upon affected growers is estimated to range from $4.0 to $15.4 million per year (Table 8). For the unaffected growers, the $1.95 to $3.90 per cwt. increase in price would increase short term annual revenue by approximately $.9 to $1.9 million. The total short term net farm income reduction for the U.S. broccoli industry (both impacted and nonimpacted growers) would range from $3.1 to $13.5 million in the first year.

The short term increase in broccoli prices would be an incentive for growers in unaffected areas to either begin or expand broccoli production in the longer term. The longer term increase in production would reduce broccoli prices from the initial impact levels. Without the development of biological and cost effective weed controls, as much as one third of the impacted acreage would be reallocated over time to less labor intensive crops such as sugar beets (70 percent) and dry beans (30 percent) (USDA/EPA/States, 1980).

Table 7. Estimated Revenue Change for U.S. Broccoli Growers Substituting Alternative Herbicides for Nitrofen

Herbicide Program	Treated Acreage	Output (cwt)	Price/Cwt ($)	Revenue ($000)
With nitrofen	66,000	5,478,000 1/	17.91 2/	98,111.0
Without nitrofen	66,000	4,847,040 3/	19.86-21.81 4/	96,262.2 -105,713.9
			Revenue Change	-1,848.8 to +7,602.9

1/ 1977-79 average output per acre (83 cwt) x 66,000 treated acres.
2/ 1977-79 weighted average price for U.S.
3/ Output of affected acreage assuming a yield reduction of 630,960 cwt. (Table 5).
4/ Estimated price range when elasticity of demand ranges between -.5 and -1.0 and short run supply curve assumed to be perfectly inelastic (Table 6).

Sources: USDA, Vegetables 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

Table 8. Short Term Farm Impact of a Nitrofen Cancellation on U.S. Broccoli Growers (1980)

Nitrofen Treated Acres	Increased Production Costs to Impacted Growers 1/ ($000)	Revenue Change for Impacted Growers 2/ ($000)	Income Loss to Impacted Growers ($000)	Income Gain to Non-Impacted Grower 3/ ($000)	Net Income Loss to Industry ($000)
66,000	11,612.2 to 13,568.6	-1,848.8 to +7,602.9	4,009.3 to 15,417.4	946.2 to 1,892.4	2,116.9 to 14,471.2

1/ See Table 4.
2/ See Table 7.
3/ Assumes 5,846 unaffected acres (1977-79) average acreage of 71,846 acres less 66,000 nitrofen treated acres) and an average yield per acre of 83 cwt (1977-79 wt. average yield).

Market and Consumer Impacts

The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of broccoli by about 637,960 cwt., about 11 percent of the 1977-79 average industry output (USDA, 1980). This short run reduction of output is expected to push up prices at both the grower and retail level. If all of the estimated increase in grower prices ($1.95 to $3.90 per cwt.) were passed onto consumers, retail prices would rise by about 2 to 4 cents per pound. Since grower prices for fresh and processed vegetables account for only about 20 to 30 percent of final retail prices (USDA, 1979), a 2 to 4 cent increase in grower prices would result in a relatively small increase in final retail prices.

In the short run, the reduced supply and slightly higher retail prices would cause some consumers to substitute other vegetables for their current broccoli purchases. In the longer run, higher grower prices would stimulate new and expanded production which would increase the supply of broccoli and reduce the initial impact on retail prices.

Social/Community Impact

Although data limitations prevent an in-depth evaluation of the social and community impacts of nitrofen suspension, several potential impacts may be noted:

1. Additional hoeing operations and mechanical cultivation required by alternative weed control programs would increase the seasonal demand for field labor and possibly bid up current wages. In some areas there could be seasonal shortages of field labor.

2. The use of alternative weed control programs or the reallocation of land to other crops could lead to an increased demand for new farm equipment and other factors of production.

3. The short run reduction of broccoli production could cause some local processors to operate at a less than optimum level of output. In some cases, processors might need to search out new, and more distant supply outlets for broccoli or reinvest in new machinery capable of processing alternative crops.

All of these short run impacts would be expected to diminish over the longer run.

Limitations of Analysis

1. There are insufficient biological and economic data for long run estimates of potential crop shifts following nitrofen cancellation.

2. This analysis assumes the availability of labor for additional hoeing operations and mechanical cultivations required by alternative weed control programs used on broccoli.

3. The price of field labor is assumed to remain constant in the short run, at $7.50 per hour.

4. Data on the elasticity of demand for fresh and processed broccoli are currently unavailable. This analysis assumes a price elasticity ranging between -.5 and -1.0.

5. Estimates of current prices and yields per acre are based on 1977-79 weighted averages.

References

Brandow, G.E. Interrelations Among Demands for Farm Products and Implications for Control of Market Supply. The Pennsylvania State University. Agricultural Experiment Station. Bulletin 680. August 1961.

Rowe, Gordon and Barbara Albertson. Tok (Nitrofen), Cultural practices for Crops, Economic Impacts (Draft). Cooperative Extension. University of California. Berkeley, California. July, 1980.

Shafer, Carl E. A Preliminary Analysis of Price and Demand Relationships for South Texas Winter Carrots. Texas A&M University. Dept. of Agricultural Economics. Inf. Report 65-1. 1965.

U.S. Department of Agriculture. Market Basket Statistics, ESCS. Washington, D.C. 1979.

U.S. Department of Agriculture. Vegetables - 1979 Annual Summary, Acreage Yield, Production, and Value. ESCS. Crop Reporting Board. Washington, D.C. June, 1980.

U.S. Environmental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. July 1980.

U.S. Department of Agriculture. U.S. Environmental Protection Agency and State Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen. Washington, D.C. 1980.

University of California. Cost and Returns Summary for Broccoli (Ventura County). Cooperative Extension Budget Generator. Davis, California. 1980.

Waugh, Frederick V.. Demand and Price Analysis. USDA. Econ. Res. Ser. Technical Bulletin No. 1316. Washington, D. C. November 1964.

Western Extension Marketing Committee. A Handbook on the Elasticity of Demand for Agricultural Products in the United States. EMC Publication No. 4. July, 1967.

SUMMARY OF PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON BRUSSELS SPROUTS

A. USE:

Nitrofen use on Brussels sprouts

B. MAJOR PESTS CONTROLLED:

annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, spergularia

C. ALTERNATIVES:

Major registered chemicals: DCPA, CDEC, AND trifluralin

Non-chemical controls: Mechanical cultivation and hand hoeing

Comparative efficacy/performance: Use of alternative herbicides would reduce yields on the affected acreage by an estimated 30 to 35 percent.

Comparative costs:

Nitrofen Program Cost/Acre ($)	Alternative Program Cost/Acre ($)	Difference in Cost/Acre ($)
203.28 - 244.25	245.43 - 371.43	42.15 - 127.18

Nitrofen programs typically include use of nitrofen in sequence with trifluralin and DCPA or with CDEC and DCPA, along with 5 mechanical cultivations and 1 hand hoeing per season.

Alternative programs typically would include the use of trifluralin and DCPA, CDEC and DCPA, or DCPA alone. The use of these alternative herbicides would usually require growers to use 2 additional mechanical cultivations and 2 additional hand hoeings per season.

D. EXTENT OF USE:

Number of Growers Using Nitrofen	Nitrofen Treated Acres	% of U.S. Brussels Sprout Acreage	Amount of Nitrofen Used Annually (lb. a.i.)
11 - 12	813	14	2,440

Nearly all of the treated acreage is located in California.

E. ECONOMIC IMPACTS:

User:

The short run economic loss to the affected growers (in terms of increased production costs and revenue losses) is estimated to range between $726 and $806 thousand per year.

Increase in production costs:	$ 52,987 - 56,691
Revenue Loss:	673,310 - 749,230
Total Economic Loss:	$726,297 - $805,921

The short run output reduction due to yield losses on the impacted acreage would increase grower prices by an estimated $1.02 to $2.03 per cwt., providing non-impacted growers with an increase in annual revenues of about $711 thousand to $1.4 million.

In the longer term, increased Brussels sprout production in nonimpacted areas could reduce market prices and impacted growers' income. Some of the impacted growers would be expeced to reallocate their land to other crops less affected by a nitrofen suspension.

Market, Consumer:

The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of Brussels sprouts by an estimated 40,034 cwt., about 5 percent of current industry output. Retail prices would be expected to rise by 1 to 2 cents per pound as a result of the reduction in supply.

In the long run, higher grower prices would stimulate new and expanded production which would increase the output of Brussels sprouts and reduce the initial impact on retail prices and supply.

Macroeconomic:

No significant macroeconomic impact is expected.

F. SOCIAL/COMMUNITY IMPACTS:

Alternative weed control programs may require additional field labor. The increased demand for field labor may bid up wages and in some cases cause shortages of field labor.

The reallocation of land to other crops may lead to an increased demand for new farm equipment and other factors of production.

Short run reductions in Brussels sprout output may cause some local processors to operate at a less than optimum level of output. In some cases, processors may need to discover out more distant sources of supply or reinvest in new machinery capable of processing alternative crops.

G. LIMITATIONS OF ANALYSIS:

Estimates of comparative efficacy of nitrofen and alternative herbicides were based on the experience of weed science specialists and not on field data. Production budget information and current data on the elasticities of demand and supply for Brussels sprouts were unavailable.

H. PRINCIPAL ANALYST AND DATE:

Allen Scheid
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON BRUSSELS SPROUTS

Current Use Analysis

EPA Registration of Nitrofen and Alternatives

Nitrofen is a selective herbicide registered for use on Brussels sprouts to control the following weeds: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, and spergularia (EPA, 1980). Nitrofen is applied to Brussels sprouts at postemergence, usually in sequence with a preplant incorporation of trifluralin or CDEC and a preemergent application of DCPA (USDA/EPA/States, 1980). Although available in an emulsifiable concentrate formulation (25EC), nitrofen is usually applied to Brussels sprouts in a wettable powder formulation (50 WP). The label directions for nitrofen use in the wettable powder formulation call for a single postemergence application at 4 to 6 pounds a.i. per acre mixed with 40 to 60 gallons of water. In the emulsifiable concentrate formulation, the label calls for a single preemergence application at 3 to 6 pounds a.i. per acre mixed with 40 to 60 gallons of water.

The major alternative herbicides registered for preplant or preemergent application on Brussels sprouts are trifluralin, DCPA, CDEC, nitralin, and bensulide. No alternative herbicides are available for use on Brussels sprouts at postemergence (EPA, 1980).

Extent of Nitrofen Use

Of approximately 5,733 acres of Brussels sprouts currently grown in the United States (1977-79 average), about 813 acres (14 percent) are treated with nitrofen (USDA/EPA/States, 1980). Assuming that the average application rate is about 3 pounds active ingredients per acre, the total amount of nitrofen applied to Brussels sprouts each year is estimated to be about 2,440 pounds active ingredient.

About 98 to 100 percent of the treated acreage is located in California where 11 or 12 growers use nitrofen on Brussels sprouts. The average size of the acreage is estimated to be about 72 acres per grower (USDA/EPA/States, 1980).

Farm Impacts

Production Cost Changes

On about 80 percent of the treated acreage (650 acres), nitrofen is used in sequence with the herbicides, trifluralin and DCPA; on the remaining 20 percent of the treated acreage (163 acres), nitrofen is used with CDEC and DCPA (USDA/EPA/States, 1980). The cost of these herbicide treatments ranges from about $108 to $124 per acre (Table 1). These herbicide treatments are usually supplemented with about five mechanical cultivations at $10-$12 per acre per time and one hand hoeing operation at $45 to $60 per acre (USDA/EPA/States, 1980).

Table 1. Current Herbicide and Application Costs Per Acre for Nitrofen Weed Control Programs on U.S. Brussels Sprouts

Weed Control Program	Timing	Application Rate (lb. of a.i./acre)	Cost/Lb. of A.I. ($)	Application Cost/Acre ($)	Herbicide and Application Cost/Acre ($)	Number of Acres Treated
Trifluralin	Preplant Incorporated	.50-.75	8.05	17.00	21.03-23.04	
DCPA	Preemergence	9.0	5.27	8.00	55.43	
Nitrofen	Postemergence	3.0	7.94	8.00	31.82	
	Total				108.28-110.29	650
CDEC	Preplant Incorporated	4	5.00	17.00	37.00	
DCPA	Preemergence	9	5.27	8.00	55.43	
Nitrofen	Postemergence	3	7.94	8.00	31.82	
	Total				124.25	163

Source: USDA/EPA/States, 1980

If nitrofen use on Brussels sprouts were cancelled, growers would be expected to substitute alternative herbicides and additional field operations. The principal alternative herbicide programs expected to be used are trifluralin and DCPA (on about 70 percent of the impacted acreage), CDEC and DCPA (on 25 percent of the impacted acreage), and DCPA (on 5 percent of the impacted acreage). The herbicide and application costs of these alternative treatments range from about $55 to $92 per acre (Table 2). On the average (for the total 813 impacted acres), the use of alternative herbicides would reduce herbicide treatment costs by about $32 per acre.

The use of alternative herbicides would be expected to provide less effective weed control than control treatments using nitrofen. In order to compensate for the reduced effectiveness of alternative herbicides, growers would typically increase the number of mechanical cultivations by 2 per season and the number of hand hoeing operations by 2 or 3 per season (USDA/EPA/States, 1980). For 95 percent of the impacted acreage (receiving 2 additional mechanical cultivations and 2 additional hand hoeings), the cost of these additional operations would rise by about $95 to $99 per acre (Table 3). For the remaining 5 percent of the impacted acreage (receiving 2 additional mechanical cultivations and 3 additional hand hoeings), the cost of these additional operations would rise by about $140 to $159 (Table 3).

The use of alternative herbicides and additional field operations on the impacted acreage would result in a net increase in production costs of about $53 to $57 thousand per year (Table 4). The average

Table 2. Current Herbicide and Application Costs Per Acre for Nitrofen Alternative Weed Control Programs on U.S. Brussels Sprouts

Weed Control Program	Timing	Application Rate (lb. of a.i./acre)	Cost/Lb. of A.I. ($)	Application Cost/Acre ($)	Herbicide and Application Cost/Acre ($)	Number of Acres Treated
Trifluralin	Preplant Incorporated	.50-.75	8.05	17.00	21.03-23.04	
DCPA	Preemergence	9	5.27	8.00	55.43	
	Total				76.46-78.47	569
CDEC	Preplant Incorporation	4	5.00	17.00	37.00	
DCPA	Preemergence	9	5.27	8.00	55.43	
	Total				92.43	203
DCPA	Preemergence	9	5.27	8.00	55.43	
	Total				55.43	41

Source: USDA/EPA/States, 1980.

Table 3. Estimated Impact of a Nitrofen Suspension on Costs for Mechanical Cultivations and Hand Hoeings of U.S. Brussels Sprouts (1980)

	Cost Per Acre With Nitrofen ($)	Cost Per Acre Without Nitrofen ($)	Change in Cost Per Acre ($)
Mechanical Cultivation	50-60 1/	70- 84 2/	20-24
Hand Hoeing	45-60 3/	120-135 4/ or 165-195 5/	75 or 120-135
Total	95-120	190-219 or 235-279	95-99 or 140-159

1/ 5 mechanical cultivations per season at $10-12/acre/time.
2/ 7 mechanical cultivations per season at $10-12/acre/time.
3/ 1 hand hoeing per season, requiring 6-8 hours of labor/acre at $7.50/hour.
4/ Without nitrofen, about 95% of the affected acreage (772 acres) would receive 1 hand hoeing requiring 6-8 hours of labor/acre and 2 additional hoeings each requiring 5 hours of labor, at $7.50/hour.
5/ Without nitrofen, about 5% of the affected acreage (41 acres) would receive 2 hand hand hoeings requiring 6-8 hours of labor/acre and 2 additional hoeings each requiring 5 hours of labor, at $7.50/hour.

Source: USDA/EPA/States, 1980.

Table 4. Preharvest Costs for U.S. Brussels Sprouts, with and without Nitrofen

Affected Acreage: 813 acres	With Nitrofen ($)	With Alternative Herbicide ($)	Change in Cost ($)
Herbicide + Application Cost 1/	90,635- 91,941	64,542- 65,685	-26,093 to -26,256
Mechanical Cultivations 2/	40,650- 48,780	56,910- 68,292	+16,260 to +19,512
Hand Hoeing 3/	36,585- 48,780	99,405-112.215	+62,820 to +63,435
Total	167,870-189,501	220,857-246,192	+52,987 to +56,691

1/ See Tables 1 and 2 for costs per acre and number of acres treated.
2/ See Table 3, notes 1 and 2.
3/ See Table 3, notes 3-5.

cost increase per acre would be about $65 to $70 per acre. Based on 1976 budget estimates for Brussels sprouts grown in California (University of California, 1976), this would represent an increase of about 4 to 5 percent in total production costs. For the average growers with about 72 acres of Brussels sprouts, the use of alternative weed control programs would increase annual production costs by about $4,680 to $5,040.

Yield and Revenue Impacts

In addition to increased production costs, Brussels sprout growers using alternative herbicides would also incur substantial yield losses on the impacted acreage. The use of trifluralin and DCPA or CDEC and DCPA without nitrofen would reduce yields by about 35 percent. The use of DCPA, alone and without nitrofen, would reduce yields by about 30 percent (USDA/EPA/States, 1980). The elimination of nitrofen control program would reduce the output of Brussels sprouts by about 40,034 cwt. per year (Table 5), a reduction of nearly 5 percent in the current U.S. annual production of 812,667 cwt. (1977-79 average).

The impact of this short run reduction in output on market prices may be estimated through an analysis of price elasticity of demand at the grower level (assuming the supply curve is perfectly inelastic in the short run). Although specific estimates of the demand price elasticities for fresh and processed Brussels sprouts are currently unavailable, past market studies of demand for farm products suggest that the demand for most commodities at the farm level is relatively

Table 5. Annual Yield Losses Resulting from a Nitrofen Suspension on U.S. Brussels Sprouts

Alternative Herbicide Treatment	Expected Number of Acres Treated	Weighted Average Yield/Acre (1977-79) (cwt)	Expected Yield Reduction /Acre (cwt)	Total Expected Yield Reduction (cwt)
Trifluralin and DCPA	569	141.7	49.6 1/	28,222
CDEC and DCPA	203	141.7	49.6 1/	10,069
DCPA	41	141.7	42.5 2/	1,743
Total	813			40,034

1/ Assuming 35% yield reduction.
2/ Assuming 30% yield reduction.

Sources: USDA, Vegetables 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

inelastic (Western Extension Marketing Committee, 1967). At the farm level, buyers tend to respond to reductions in supply by bidding up the market price at a rate that is higher than the rate of output reduction. The relative inelasticity of demand for Brussels sprouts and other vegetables may be explained by the fact that they have few good substitutes and that their purchase constitutes a small part of the consumers' overall budget.

Studies of demand for vegetable crops such as cabbage, carrots, celery, tomatoes, and peppers have provided estimates of price elasticity at the farm level ranging from -.45 to -1.03 (Brandow, 1961; Waugh, 1964; Shafer, 1965). Based on these estimates of elasticity, this analysis has assumed that the farm level elasticity of demand for fresh and processed Brussels sprouts falls within the range of -.5 and -1.0. Under this assumption, the estimated yield reduction on the impacted acreage (40,034 cwt.) would cause grower prices to increase by about $1.02 to $2.03 per cwt. (Table 6). For the impacted growers, this price increase would not be sufficiently high to offset revenue losses due to reduced production. Affected growers would incur a loss of revenue estimated at about $673 to $749 thousand per year (Table 7).

In the short run, the net economic loss (in terms of increased production costs and revenue losses) to affected growers is estimated to range from about $726 to $806 thousand per year (Table 8). For the

Table 6. Estimated Change in Grower Prices Resulting from a Reduction in Brussels Sprouts Production

Elasticity 1/	Brussels Sprouts Production 2/	Reduced Brussels Sprouts Production 3/	Industry Price/Cwt 4/	Expected Price Change/Cwt 5/
(E)	(Q) cwt	(ΔQ) cwt	(P) $	(ΔP) $
-.5	812,667	40,034	20.63	+2.03
-1.0	812,667	40,034	20.63	+1.02

1/ The price elasticity of demand is assumed to range between -.5 and -1.0, based on past studies of demand for vegetables such as cabbage, carrots, celery, and peppers.

2/ 1977-79 average for U.S.

3/ Output reduction resulting from 30-35% yield reduction on affected acreage (Table 5).

4/ 1977-79 weighted average price for U.S.

5/ Calculated from the equation: Elasticity of Demand = $-\dfrac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$

Sources: USDA, Vegetables 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

Table 7. Estimated Short Run Revenue Change for U.S. Brussels Sprouts Growers Substituting Alternative Herbicides for Nitrofen

Herbicide Program	Treated Acreage	Output (cwt)	Price/cwt ($)	Revenue ($)
With nitrofen	813	115,202 1/	20.63 2/	2,376,617
Without nitrofen	813	75,168 3/	21.65-22.66 4/	1,627,387-1,703,307
			Revenue Change	-673,310 to -749,230

1/ 1977-79 average output per acre (141.7 cwt.) x 813 treated acres.
2/ 1977-79 weighted average price for U.S.
3/ Output of affected acreage assuming a total output reduction of 40,034 cwt. (Table 5).
4/ Estimated price range when the price elasticity of demand ranges between -.5 and -1.0 and the short run supply curve is assumed to be perfectly inelastic (Table 6).

Sources: USDA, Vegetables 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

Table 8. Short Term Economic Impact of a Nitrofen Suspension on U.S. Brussels Sprout Growers (1980)

Nitrofen Treated Acres	Increased Production Costs to Impacted Growers 1/ ($)	Revenue Loss to Impacted Growers 2/ ($)	Income Loss to Impacted Growers 3/ ($)	Income Gain to Nonimpacted Growers 4/ ($)	Net Impact on Industry Income ($)
813	52,987 to 56,691	-673,310 to -749,230	726,297 to 805,921	711,107 to 1,415,243	-94,814 to +688,946

1/ See Table 4.
2/ See Table 7.
3/ Sum of increased production costs and revenue loss.
4/ Assumes 4,920 unaffected acres (1977-79 average acreage of 5,733 acres less 813 nitrofen treated acres), an average yield of 141.7 cwt per acre, and a price increase of $1.02 to $2.03.

unaffected growers, the $1.02 to $2.03 per cwt. increase in price would increase short term annual revenue by approximately $711 thousand to $1.4 million. During the first year after a nitrofen suspension, the overall economic impact on the Brussels sprout industry (impacted and nonimpacted growers) would range from a net loss of about $95,000 (if price rose by $1.02 per cwt.) to a net gain of about $688,946 (if price rose by $2.03 per cwt.).

The short term increase in Brussels sprout prices would be an incentive for growers in unaffected areas to either begin or expand production. In the long run, this increased production would reduce farm prices from the initial impact level. Without the development of biological and cost effective weed controls, some of the impacted growers would be expected to reallocate their land to other crops less affected by a nitrofen suspension.

Market and Consumer Impacts

The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of Brussels sprouts by about 40,034 cwt., about 5 percent of the 1977-79 average industry output (USDA, 1980). This short run reduction of output would be expected to have a relatively small impact on prices at the retail level. If all of the estimated increase in grower prices ($1.02 to $2.03 per cwt.) were passed on to consumers, retail prices would rise by about 1 to 2 cents per pound. Since grower prices for fresh and processed vegetables

account for only about 20 to 30 percent of final retail prices (USDA, 1979), a $1.02 to $2.03 per cwt. increase in grower prices would result in an increase of about 1-3 percent in final retail prices.

In the short run, the reduced supply and slightly higher retail prices would cause some consumers to substitute other vegetables for their current purchases of Brussels sprouts. In the long run, higher grower prices would stimulate new and expanded production which would increase the output of Brussels sprouts and reduce the initial impact on retail prices and supply.

Social/Community Impact

Although data limitations prevent an in-depth evaluation of the social and community impacts of nitrofen suspension, several potential impacts may be noted:

1. Additional hoeing operations and mechanical cultivation required by alternative weed control programs would increase the seasonal demand for field labor and possibly bid up current wages. In some areas there could be seasonal shortages of field labor.

2. The use of alternative weed control programs or the reallocation of land to other crops could lead to an increased demand for new farm equipment and other factors of production.

3. The short run reduction of Brussels sprouts production could cause some local processors to operate at a less than optimum level of output. In some cases, processors might need to search out new, and more distant supplies of Brussels sprouts or reinvest in new capital capable of processing alternative crops.

All of these short run impacts would be expected to diminish over the longer run.

Limitations of Analysis

1. There are insufficient biological and economic data for long run estimates of potential crop shifts following a nitrofen suspension.

2. This analysis assumes that adequate supplies of labor for additional hoeing operations and mechanical cultivations are available for the alternative weed control programs used on Brussels sprouts.

3. The price of field labor is assumed to remain constant in the short run, at $7.50 per hour.

4. Data on the elasticity of demand for fresh and processed Brussels sprouts are currently unavailable. This analysis assumes a price elasticity ranging between -.5 and -1.0.

5. Estimates of current prices and yields per acre are based on 1977-79 weighted averages.

References

Brandow, G.E. Interrelations Among Demands for Farm Products and Implications for Control of Market Supply. The Pennsylvania State University. Agricultural Experiment Station. Bulletin 680. August 1961.

Rowe, Gordon and Barbara Albertson. Tok (Nitrofen), Cultural practices for Crops, Economic Impacts (Draft). Cooperative Extension. University of California. Berkeley, California. July, 1980.

Shafer, Carl E. A Preliminary Analysis of Price and Demand Relationships for South Texas Winter Carrots. Texas A&M University. Dept. of Agricultural Economics. Inf. Report 65-1. 1965.

U.S. Department of Agriculture. Market Basket Statistics, ESCS. Washington, D.C. 1979.

U.S. Department of Agriculture. Vegetables - 1979 Annual Summary, Acreage Yield, Production, and Value. ESCS. Crop Reporting Board. Washington, D.C. June, 1980.

U.S. Environmental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. July 1980.

U.S. Department of Agriculture. U.S. Environmental Protection Agency and State Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen. Washington, D.C. 1980.

University of California. Brussels Sprout Production in the Central Coast District - 1976. Cooperative Extension Work in Agriculture and Home Economics. Santa Cruz, California. 1976.

Waugh, Frederick V.. Demand and Price Analysis. USDA. Econ. Res. Ser. Technical Bulletin No. 1316. Washington, D. C. November 1964.

Western Extension Marketing Committee. A Handbook on the Elasticity of Demand for Agricultural Products in the United States. EMC Publication No. 4. July, 1967.

SUMMARY OF PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON CABBAGE

A. USE: Nitrofen use on cabbage

B. MAJOR PESTS CONTROLLED: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, spergularia

C. ALTERNATIVES:

Major registered chemicals: Trifluralin, DCPA, bensulide, CDEC

Non-chemical controls: Mechanical cultivation and hand hoeing.

Comparative efficacy/performance: For about 90 percent of the treated acreage, the use of alternative weed control programs would reduce yields by about 0 to 30 percent. For 10 percent of the treated acreage (in the Southeast), the use of alternative weed control programs would not be expected to reduce yields.

Comparative costs:

Nitrofen Programs Herbicide Cost/Acre ($)	Alternative Programs Herbicide Cost/Acre ($)
23.88 - 153.46	21.03 - 113.70

Nitrofen weed control programs include the use of nitrofen alone or in sequence with other herbicides such as trifluralin, bensulide, DCPA, or CDEC. Alternative weed control programs include the use of trifluralin, DCPA, and CDEC alone or the use of DCPA in sequence with bensulide.

The use of an alternative weed control program would typically require growers to use 1-2 additional mechanical cultivations and/or hand hoeings per season. On the average, the use of alternative weed control programs would increase production costs by $50.14 to $52.90 per acre.

D. EXTENT OF USE: Amount of nitrofen applied to cabbage is estimated at 91,462 to 182,924 pounds a.i. per year. Nitrofen treated accreage is estimated at 45,731 acres, about 44% of total U.S. cabbage acreage. Estimates of annual usage by specific sites is as follows:

States	Acres Treated	% of State Cabbage Acreage	Quantity of Nitrofen Applied (lb. a.i.)
Florida	12,135	69	24,270 - 48,540
Texas	6,500	33	13,000 - 26,000
California	5,618	71	11,236 - 22,472
Wisconsin	5,167	100	10,334 - 20,668
Michigan	3,767	100	7,534 - 15.068
Ohio	3,570	90	7,140 - 14,280
Other States	8,974	33	17,948 - 35,896
Total	45,731		91,462 -182,924

E. ECONOMIC IMPACTS:

User: The substitution of alternative weed control programs would increase production costs on the affected acreage by about $2.3 to $2.4 million per year. Expected output reduction on the treated acreage would result in a short run increase in grower prices, ranging from an estimated $1.35 to $2.13 per cwt. Depending on the level of the price increase, the estimated change in the annual revenue of affected growers would range from a revenue increase of about $3.0 million to a revenue loss of about $3.4 million. The net economic impact on affected growers would range from an economic gain of about $695 thousand to an economic loss of about $5.9 million per year. For the nonimpacted grower, annual revenues would increase by $18.3 to $28.8 million in the short run.

In the longer term, increased production in nonimpacted areas could reduce market prices and grower revenue. Some of the impacted growers would be expected to reallocate their land to other crops less affected by a nitrofen suspension.

Market/Consumer: The use of alternative herbicides in place of nitrofen would reduce the short run supply of cabbage by about 1.7 million cwt., about 9 percent of the 1977-79 average industry output. Retail prices would be expected to rise by about 1 to 2 cents per pound. In the long run, higher prices at the grower level would stimulate new and expanded production which would increase the supply of cabbage and reduce the initial impact on retail prices.

Macroeconomic: No significant macroeconomic impact is expected.

F. SOCIAL/COMMUNITY IMPACTS: Alternative weed control programs may require additional field labor. The increased demand for field labor may bid up wages and in some cases cause shortages of field labor.

The reallocation of land to other crops may lead to an increased demand for new farm equipment and other factors of production.

Short run reductions in cabbage output may cause some local processors to operate at a less than optimum level of output. In some cases, processors may need to search out more distant supply outlets or reinvest in new machinery capable of processing alternative crops.

G. LIMITATIONS OF ANALYSIS: Estimates of comparative efficacy of nitrofen and alternative herbicides were based on the experience of weed science specialists and not on field data. Up-to-date estimates on price elasticity of demand were unavailable.

H. PRINCIPAL ANALYST AND DATE:

Allen Scheid
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

January 1981

Preliminary Benefit Analysis of Nitrofen Use on Cabbage

Current Use Analysis

EPA Registration of Nitrofen and Alternatives

Nitrofen is a selective herbicide registered for use on cabbage to control the following weeds: annual bluegrass, crabgrass, goosefoot, lambquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, and spergularia (EPA, 1980). Nitrofen is applied to cabbage at pre- or postemergence, usually in sequence with the herbicides DCPA or trifluralin (USDA/EPA/States, 1980). Although available in an emulsifiable concentrate formulation (25EC), nitrofen is commonly applied to cabbage in a wettable powder formulation (50WP). The label directions for nitrofen use in the wettable powder formulation call for a single pre- or postemergence application at 3 to 6 pounds a.i. per acre mixed with 40 to 60 gallons of water.

The major alternative herbicides registered for preplant or preemergent application on cabbage are trifluralin, DCPA, CDEC, nitralin, and bensulide. In Wisconsin, Illinois, Indiana, and Florida, the herbicide CDAA is also registered for pre- or postemergent application on cabbage (EPA, 1980).

Extent of Nitrofen Use

Approximately 103,517 acres of cabbage are currently grown in the United States (1977-79 average). About 44 percent of this acreage (45,731 acres) is treated with nitrofen (USDA/EPA/States, 1980). Assuming an application rate of 2 to 4 pounds a.i. per acre, the total amount of nitrofen applied to cabbage each year is about 91,462 to 182,924 pounds a.i.

Throughout the United States there are about 1,079 growers using nitrofen on cabbage. The average size of the cabbage acreage per farm is about 42 acres (USDA/EPA/States, 1980). About 80 percent of the treated acreage is located in the major cabbage producing states of Florida, Texas, California, Wisconsin, Michigan and Ohio.

Economic Impact Analysis

Farm Impacts

Production Cost Changes

Nitrofen is typically used on cabbage in sequence with other herbicides such as trifluralin, bensulide, DCPA, or CDEC (Table 1). In some areas of Florida, nitrofen is used alone. The cost of the nitrofen weed control programs on cabbage is estimated to be about $2.7 to $3.8 million per year (Table 2).

Table 1. Estimated Use of Nitrofen Herbicide Programs on Cabbage, by Region and States

Nitrofen Program	Treated Acres	Region/States
A. trifluralin, nitrofen	24,482	North Central: Michigan, Wisconsin, Ohio, Indiana, Illinois Northeast: New Jersey, Massachusetts, Maryland, Southeast: North Carolina, South Carolina, Georgia, Virginia, Tennessee, Florida
B. bensulide, DCPA, nitrofen	6,500	Southwest: Texas
C. DCPA, nitrofen	7,468	North Central: Wisconsin, Ohio, Indiana, Illinois Northeast: New Jersey, Massachusetts, Maryland West: California, Oregon, Hawaii
D. nitrofen (alone)	4,854	Southeast: Florida
E. CDEC, nitrofen	2,427	Southeast: Florida
Total	45,731	

Source: USDA/EPA/States, 1980

Table 2. The Cost of Nitrofen Weed Control Programs Used on Cabbage

Weed Control Program	Application Rate (lbs. of a.i.)	Cost Per Lb. of A.I. ($)	Application Cost Per Acre ($)	Herbicide & Application Cost Per Acre ($)	Number of Acres Treated 1/	Total Cost ($)
A. trefluralin	.5 - 1.0	8.05	17	21.03-25.05		
nitrofen	2.0 - 4.0	7.94	8	23.88-39.76		
				44.91-64.81	24,482	1,099,487-1,586,678
B. bensulide	4.0 - 6.0	5.56	17	39.24- 50.36		
DCPA	8.0 - 10.5	5.27	8	50.16- 63.34		
nitrofen	2.0 - 4.0	7.94	8	23.88- 39.76		
				113.28-153.46	6,500	736,320- 997,490
C. DCPA	8.0 -10.5	5.27	8	50.16- 63.34		
nitrofen	2.0 - 4.0	7.94	8	23.88- 39.76		
				74.04-103.10	7,468	552,931- 769,951
D. nitrofen	2.0 - 4.0	7.94	8	23.88- 39.76	4,854	115,914- 192,995
E. CDEC	4.0 - 6.0	5.00	17	37.00- 47.00		
nitrofen	2.0 - 4.0	7.94	8	23.88- 39.76		
				60.88- 86.76	2,427	147,756- 210,567
				Total	45,731	2,652,408-3,757,681

1/ See table 1 for regions and states where treated acreage is located.

Source: USDA/EPA/States, 1980

If nitrofen use on cabbage were cancelled, growers would be expected to substitute alternative herbicide programs with trifluralin, bensulide, DCPA, or CDEC (Table 3). The total cost of using these alternative programs on the affected acreage is estimated to be about $1.8 to $2.2 million per year (Table 4). In order to compensate for the reduced effectiveness of the alternative herbicides, growers would typically increase the number of mechanical cultivations and/or hand hoeings used during the growing season (USDA/EPA/States, 1980). The cost of these additional field operations on the affected acreage would be about $3.3 to $3.9 million per season (Table 5), and the net increase in annual production costs would be about $2.3 to $2.4 million (Table 6). This represents an increase of about $50 to $53 per acre in production costs.

Based on 1980 budget estimates for cabbage grown in California (University of California, 1980), a $50 to $53 increase in production costs (resulting from the use of alternative weed control programs) would represent an increase of about 2 percent in total production costs per acre. For the average grower with about 42 acres of cabbage, the use of alternative weed control programs would increase annual production costs by about $2,100 to $2,226.

Yield and Revenue Impacts

In addition to increased production costs, cabbage growers using alternative herbicides would also incur yield losses on the impacted acreage. The use of alternative weed control programs in place of nitrofen

Table 3. Estimated Use of Alternative Herbicide Programs on Cabbage by Region and States

Alternative Program	Treated Acres	Regions/States
A. trifluralin	25,373	North Central: Michigan, Wisconsin, Ohio, Indiana, Illinois Northeast: New Jersey, Massachusetts, Maryland Southeast: North Carolina, South Carolina, Georgia, Virginia, Tennessee, Florida
B. bensulide, DCPA	6,500	Southwest: Texas
C. DCPA	9,004	North Central: Wisconsin, Ohio, Indiana, Illinois Northeast: New Jersey, Massachusetts, Maryland West: California, Oregon, Hawaii
D. CDEC	4,854	Southeast: Florida
Total	45,731	

Source: USDA/EPA/States, 1980

Table 4. The Cost of Alternative Weed Control Programs Used on Cabbage

Weed Control Program	Application Rate (lb. of a.i.)	Cost Per Lb. of A.I. ($)	Application Cost Per Acre ($)	Herbicide & Application Cost Per Acre ($)	Expected Number of Acres Treated 1/	Total Cost ($)
A. trifluralin	.5-1.0	8.05	17	21.03- 25.05	25,373	553,594 - 635,594
B. DCPA	8.0-10.5	5.27	8	50.16- 63.34	9,004	451,641 - 570,313
C. bensulide	4.0-6.0	5.56	17	39.24- 50.36	6,500	581,100 - 739.050
DCPA	8.0-10.5	5.27	8	50.16- 63.34		
				89.40-113.70		
D. CDEC	4.0-6.0	5.00	17	37.00-47.00	4,854	179,598 - 228,138
				Total	45,731	1,765,933 - 2,173,095

1/ See Table 3 for regions and states where treated acreage is located.

Source: USDA/EPA/States, 1980

Table 5. Estimated Impact of a Nitrofen Suspension on Costs for Mechanical Cultivations and Hand Hoeings on U.S. Cabbage

State/Region	Alternative Weed Control Program	Expected Number of Acres Treated	Cost Per Acre for Additional Mechanical Cultivation 1/ ($)	Cost Per Acre for Additional Hand Hoeing 2/ ($)	Cost for Additional Mechanical Cultivation and/or Hand Hoeing on Affected Acreage ($)
California and Oregon	DCPA	5,822	20-24	150-180	989.740 - 1,187,688
Florida	Trifluralin or CDEC	12,135	10-12	0	121,350 - 145.620
Michigan	Trifluralin	3,767	20-24	82-98.40	384,234 - 461,081
Texas	Bensulide and DCPA	6,500	0	40.00	260,000
Northeast and North Central 3/	Trifluralin or DCPA	12,457	20-24	86-103.20	1,320,442 - 1,584,530
Southeast 4/	Trifluralin	4,650	0	40.00	186,000
Hawaii	DCPA	400	20-24	90-108	44,000 - 52,800
	Total	45,731			3,305,766 - 3,877,719

1/ Cost of mechanical cultivation estimated to be $10-12/acre/time.
2/ For most areas the hand hoeing operation requires about 10-12 hours of field labor/acre/time.
3/ Pennsylvania, New Jersey, Maryland, Massachusetts, Wisconsin, Ohio, Indiana, Illinois.
4/ North Carolina, South Carolina, Georgia, Virginia, Tennessee.

Source: USDA/EPA/States, 1980

Table 6. Net Increase in Production Costs for Cabbage Growers Substituting Alternative Weed Control Programs for Nitrofen Weed Control Programs

Herbicide Cost Reduction 1/	-886,475 to -1,584,586
Mechanical Cultivation and Hand Hoeing Cost Increase 2/	+3,305,766 to +3,877,719
Net Production Cost Increase	+2,293,133 to +2,419,291

1/ Estimated cost of nitrofen programs (Table 2) less the cost of alternative herbicide programs (Table 4).

2/ See Table 5.

programs would reduce the output of cabbage by about 1.7 million cwt. per year (Table 7), a reduction of nearly 9 percent in the current U.S. annual production of 19,522,000 cwt. (1977-79 average).

The impact of this short run reduction in output on market prices and grower revenue may be estimated through an analysis of the price elasticity of demand which measures the percentage change in quantity demanded associated with a percentage change in prices of the same product. Although current estimates of price elasticity are unavailable, past market studies of cabbage and other vegetables suggest that demand at the farm level is relatively inelastic (Brandow, 1961; Waugh, 1964; Shaefer, 1965). At the farm level, buyers tend to respond to reductions in supply by bidding up the market price at a rate that is higher than the rate of output reduction. This relative inelasticity of demand may be explained by the fact that cabbage has few good substitutes and its purchase constitutes a small part of the consumer's food budget.

Brandow's study of demand for cabbage during 1949 to 1959 (Brandow, 1961) estimated the price elasticity of demand at the farm level to be -.45. If this estimate reflects current demand, the estimated supply reduction (resulting from the use of alternative herbicide programs) would cause grower prices to rise by about $1.66 per cwt. (Table 8). For most of the impacted growers, this price increase would not be sufficiently high to offset revenue losses due to reduced production. In the aggregate, the affected growers would incur a loss of revenue estimated at about $831,000 per year (Table 9). If price elasticity falls within the range of -.35 to -.55, the estimated yield reduction would cause grower prices to rise by

Table 7. Annual Yield Reduction Resulting from a Nitrofen Suspension on U.S. Cabbage

State/Region	Alternative Weed Control Program	Expected Number of Acres Treated	Average Yield Per Acre (1977-79) (cwt)	Yield Reduction on Treated Acreage Percent	Yield Reduction on Treated Acreage Cwt
California and Oregon	DCPA	5,822	234	30	408,704
Florida	Trifluralin and CDEC	12,135	233	10	282,746
Michigan	Trifluralin	3,767	145	10	54,622
Texas	Bensulide and DCPA	6,500	240	25	390,000
Northeast and North Central 1/	Trifluralin or DCPA	12,457	226	20	563,056
Southeast 2/	Trifluralin	4,650	153	0	0
Hawaii	DCPA	400	298	10	11,920
Total		45,731			1,711,048

1/ Pennsylvania, New Jersey, Maryland, Massachusetts, Wisconsin, Ohio, Indiana, Illinois.
2/ North Carolina, South Carolina, Georgia, Virginia, Tennessee.

Sources: USDA, Vegetables 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

Table 8. Estimated Change in Grower Prices Resulting from a Reduction in Cabbage Production

Cabbage Production 1/ (cwt)	Reduced Cabbage Production 2/ (cwt)	Current Farm Level Price Per Cwt 3/ ($)	Price Elasticity of Demand at the Farm Level 4/ ($)	Expected Price Increase Per Cwt 5/ ($)
19,522,000	1,711,048	8.50	-.35	2.13
			-.40	1.86
			-.45	1.66
			-.50	1.49
			-.55	1.35

1/ [illegible]

2/ Output reduction resulting from use of alternative weed control programs (Table 5)

3/ 1977-79 U.S. average

4/ Price elasticity of demand at the farm level is assumed to range between -.35 and -.55. This range is based on elasticity estimates made by Foote (1956) and Brandow (1961).

5/ Calculated from the equation: Elasticity of Demand = $-\dfrac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$

Source s: USDA, Vegetables 1979 Annual Summary, 1980
USDA/EPA/States, 1980

Table 9. Revenue Impact of Nitrofen Suspension on the Affected Cabbage Growers

	Treated Acreage	Output (cwt)	Price Elasticity of Demand at Farm Level	Price Per Cwt 3/ ($)	Total Revenue ($)	Revenue Change ($)
With Nitrofen						
	45,731	9,941,950 1/	- - -	8.50	84,506,575	
Without Nitrofen						
	45,731	8,230,902 2/	- .35	10.63	87,494,488	+ 2,987,931
			- .40	10.36	85,272,145	+ 765,570
			- .45	10.16	83,625,964	- 880,611
			- .50	9.99	82,226,711	- 2,279,864
			- .55	9.85	81,074,385	- 3,432,190

1/ The expected number of acres treated x the average yield per acre in each state or region (Table 5).
2/ Output on affected acreage, assuming a total output reduction of 1,711,048 cwt. (Table 5).
3/ Elasticity of demand at grower level assumed to range between - .35 to -.55.

about $1.35 to $2.13 per cwt. (Table 8). The revenue impact on the affected growers would range from a revenue increase of about $3.0 million (assuming a price elasticity of -.35) to a revenue loss of about $3.4 million (assuming a price elasticity of -.55) (Table 9).

In the short run, the net economic impact on the affected growers would range from a net income increase of about $695 thousand to a net income loss of about $5.9 million (Table 10). On a per acre basis, the net revenue impact would range from an increase of about $15 to a net loss of about $128 per acre. For the average grower with 42 acres of cabbage, the net revenue impacts would range from an increase of about $630 to a net loss of about $5,376 per season.

For the unaffected growers, a price increase of $1.35 to $2.13 per cwt. at the farm level would increase annual revenues by about $18.3 to $28.8 million, an increase of about $316 to $498 per acre. In the short run, the average non impacted grower (with 42 acres of cabbage) would receive a revenue increase of about $13,272 to $20,916 per season.

The short term increase in cabbage prices would be an incentive for growers in unaffected areas to either begin or expand production. In the long run, this increased production would reduce farm prices from the initial impact level. Without the development of biological and cost effective weed controls, long term income losses would probably cause some impacted growers to reallocate their land to other crops less affected by a nitrofen suspension.

Table 10. Short Term Economic Impact of a Nitrofen Suspension on U.S. Cabbage Growers (1980)

	Impacted Growers	Non-Impacted Growers	Industry
Change in Production Costs ($000)	+2,293.1 to +2,419.3 1/	0	+2,293.1 to + 2,419.3
Change in Grower Revenue ($000)	+2,987.9 to -3,432.2 2/	+18,254.6 to 28,801.7 3/	+14,822.4 to +31,789.6
Net Income Change ($000)	+ 694.8 to -5,851.5	+18,254.6 to 28,801.7	+12,403.1 to +29,496.5

1/ See Table 6.
2/ See Table 9.
3/ Assumes 57,786 unaffected acres (1977-79 average acreage of 103,517 acres (USDA, 1980) less 45,731 treated acres), an average yield of 234 cwt per acre (USDA, 1980), and a price increase of $1.35 to $2.13 per cwt.

Market and Consumer Impacts

The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of cabbage by about 1.7 million cwt. (Table 5), about 9 percent of the 1977-79 average industry output of 19.5 million cwt (USDA, 1980). This short run reduction of output would be expected to have a relatively small impact on prices at the retail level. If all of the estimated increase in grower prices ($1.35 to $2.12 per cwt.) were passed on to consumers, retail prices would rise by about 1 to 2 cents per pound. Since grower prices for fresh and processed vegetables account for only about 20 to 30 percent of final retail prices (USDA, 1979), a $1.35 to $2.12 per cwt. increase in grower prices would result in an increase of about 3 to 7 percent in final retail prices.

In the short run, the reduced supply and higher retail prices would cause some consumers to substitute other vegetables for their current purchases of cabbage. In the long run, higher grower prices would stimulate new and expanded production which would increase the output of cabbage and reduce the initial impact on retail prices and supply.

Macroeconomic Impacts

The suspension of nitrofen use on cabbage would not be expected to have any significant macroeconomic impacts.

Social/Community Impact

Although data limitation prevent an in-depth evaluation of the social and community impacts of nitrofen suspension, several potential impacts may be noted:

1. Additional hoeing operations and mechanical cultivation required by alternative weed control programs would increase the seasonal demand for field labor and possibly bid up current wages. In some areas there could be seasonal shortages of field labor.

2. The use of alternative weed control programs or the reallocation of land to other crops could lead to an increased demand for new farm equipment and other factors of production.

3. The short run reduction of cabbage production could cause some local processors to operate at a less than optimum level of output. In some cases, processors might need to discover new, more distant suppliers of cabbage or reinvest in new capital equipment capable of processing alternative crops. The major cabbage producing states for the processing market are New York, Wisconsin, and Ohio.

Limitations of Analysis

1. There are insufficient biological and economic data for long run estimates of potential crop shifts following a nitrofen suspension.

2. This analysis assumes that adequate supplies of labor for additional hoeing operations and mechanical cultivations are available at the existing wage rates.

3. Data on the elasticity of demand for fresh and processed cabbage are currently unavailable. The estimated impact on grower revenue is very sensitive to the estimated range of current price elasticity of demand. This analysis has assumed the price elasticity of demand to range between -.35 to -.55. The mid-point of this range is -.45 which is the elasticity estimate provided by Brandow in his study of the demand for cabbage during the period of 1949 to 1959 (Brandow, 1961).

4. Estimates of current prices and yields are based on 1977-79 averages.

5. Budget estimates for cabbage production were only available for California.

6. Estimates of comparative efficacy of nitrofen and alternative herbicides were based on the experience of weed science specialists and not on field data.

SUMMARY OF PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON CARROTS

A. USE: Nitrofen use on carrots

B. MAJOR PESTS CONTROLLED:

annual bluegrass	lambsquarters	nettle	shepherdspurse
crabgrass	malva	pigweed	spergularia
goosefoot	nightshade	purslane	

C. ALTERNATIVES:

Major registered chemicals:

bensulide	chloroxuron	mineral spirits
chloropropham	linuron	trifluralin

Non-chemical controls: Mechanical cultivation and hand hoeing.

Comparative efficacy/performance: The use of alternative herbicides would reduce yield on the impacted acreage by an estimated 10 percent.

Comparative costs:

State(s)	Nitrofen Program Cost/Acre	Alternative Program Cost/Acre	Cost Difference/ $ Acre
Arizona	$ 68.36- 83.36	$ 90.64-105.64	+22.28
California	53.36- 76.40	75.64	-.76 to +22.28
Florida	216.28-288.08	263.60-324.60	+36.52 to +47.32
Michigan, Minnesota, and Wisconsin	166.58-229.88	227.60-326.70	+50.22 to +107.62
Indiana, Ohio	188.12-271.72	233.80-339.00	+20.68 to +94.28

Nitrofen programs typically include use of nitrofen in sequence with one or more herbicides such as trifluralin, linuron, paraquat, and mineral spirits.

Alternative programs typically include the sequential application of herbicides, such as trifluralin, linuron, paraquat, and mineral spirits.

D. EXTENT OF USE: Amount of nitrofen applied to carrots is estimated at 158,500 pounds a.i. per year. Nitrofen treated acreage is estimated at 31,950 acres, about 41% of total U.S. carrot acreage. Estimates of annual usage by specific states is as follows:

States	Acres Treated	% of State(s) Carrot Acreage	Quantity of Nitrofen Applied (lb. A.I.)
California, Arizona	12,000	33	48,000
Florida	14,000	95	98,000
Michigan, Minnesota Wisconsin	5,350	40	10,700
Ohio, Indiana	600	75	1,800
Total	31,950		158,500

E. ECONOMIC IMPACTS:

User: The suspension of nitrofen and the consequent use of alternative weed control programs would increase production costs on the affected acreage by about $922 thousand to $1.1 million per year. Carrot output on the treated acreage would be reduced by about 10%, with a consequent revenue loss for the impacted growers estimated to range between $714 thousand and $3.8 million per year. The short run economic loss to the affected growers (in terms of increased production costs and revenue losses) is estimated to range between $1.6 and $4.9 million per year. The short run economic impact on the U.S. carrot industry would range from a net loss of about $1 million to a net gain of about $6.3 million per year.

Market/ Consumer: In the longer term, increased carrot production in nonimpacted areas could reduce market prices and impacted growers' income. Some of the impacted growers would be expected to reallocate their land to other crops less affected by a nitrofen suspension.

The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of carrots by about 991,655 cwt., about 5 percent of current industry output. Short run retail prices would be expected to rise by less than 1¢ per pound as a result of the reduction in supply.

In the long run, higher grower prices would stimulate new and expanded production which would increase the output of carrots and reduce the initial impact on retail prices and supply.

Macroeconomic: No significant macroeconomic impact expected.

F. SOCIAL/COMMUNITY IMPACTS: Alternative weed control programs may require additional field labor. The increased demand for field labor may bid up wages and in some cases cause shortages of field labor.

The reallocation of land to other crops may lead to an increased demand for new farm equipment and other factors of production.

Short run reductions in carrot output may cause some local processors to operate at a less than optimum level of output. In some cases, processors may need to discover more distant source of supply or reinvest in new machinery capable of processing alternative crops.

G. LIMITATIONS OF ANALYSIS: Estimates of comparative efficacy of nitrofen and alternative herbicides are based on the experience of weed science specialists and not on field data. Production budget information and current data on the elasticity of demand for carrots were unavailable.

H. PRINCIPAL ANALYSTS AND DATE:

Allen Scheid
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

Michael Hanthorn
Pest Control Branch
Natural Resource Economics Division
Economics and Statistics Service
U.S. Department of Agriculture

January 1981

Preliminary Benefit Analysis of Nitrofen Use on Carrots

Current Use Analysis

EPA Registration of Nitrofen and Alternatives

Nitrofen, formulated as an emulsifiable concentrate (25 percent active ingredient), is registered for use on carrots to control a variety of weeds including: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, and spergularia. The label directions for the use of nitrofen on carrots call for a single pre- or postemergence spray application at two to six pounds a.i. per acre mixed with 40 to 60 gallons of water (EPA, 1980).

The major alternative herbicides registered for use on carrots are: bensulide, chloropropham, chloroxuron, linuron, petroleum distillate (mineral spirits), and trifluralin (EPA, 1980).

Use of Nitrofen and Alternatives

Of approximately 78,000 acres of carrots currently grown in the United States, nearly 32,000 acres (41 percent) are treated with nitrofen. Almost two thirds of the treated acreage (19,950 acres) consists of muck soils in Florida, Indiana, Michigan, Minnesota, Ohio and Wisconsin. The remainder of the treated acreage (12,000 acres) is

composed of mineral soils in Arizona and California. About 185,500 pounds a.i. of nitrofen are used on carrots each year in these states (USDA/EPA/States, 1980).

The typical nitrofen weed control program for carrots includes a preemergence and/or post emergence application of nitrofen used in sequence with other herbicides. On the mineral soils of Arizona and California, nitrofen is used in sequence with trifluralin and/or linuron. On the muck soils of Florida, Indiana, Michigan, Minnesota, Ohio, and Wisconsin, nitrofen is used in sequence with linuron. Nitrofen treatments are usually supplemented with one or two mechanical cultivations in all states except California and with one or two spot hoeings in all states except Arizona and California.

Without nitrofen, weed control programs on mineral soils usually require an additional mechanical cultivation per season (Table 1). The loss of nitrofen on muck soils would require an increase of one mechanical cultivation, 1-2 hand hoeings, and 1 irrigation per season (Table 1). With the use of alternative weed control programs, annual carrot yields would be expected to decline by 10 percent (USDA/EPA/States, 1980).

Table 1. Use of Nitrofen and Alternative Weed Control Programs on Carrots 1/

State Weed Control Program	Total Acres Treated	Number of Hand Hoeings	Number of Mechanical Cultivations	Number of Irrigations
Arizona, California (mineral soils)				
With nitrofen 1/	12,000	0	1-2 3/	0
Without nitrofen 4/		0 5/	1 6/, 2-3 7/	0
Florida, Indiana, Michigan, Minnesota Ohio, Wisconsin (muck soils)				
With nitrofen 8/	19,950	1-2	1-2	6
Without nitrofen 9/		2-3	2-3	7

1/ USDA/EPA/States Assessment Team on Nitrofen, 1980.
2/ Nitrofen is applied as a preemergent spray in sequence with trifluralin as a preplant incorporated and linuron as a postemergent spray.
3/ Arizona only.
4/ Linuron replaces nitrofen as a preemergent spray in the sequence described in footnote 2.
5/ Harry Agamalian Farm Advisor (Weed Scientist) - Monterey County - Agricultural Extension Service, University of California, Salinas, California 93901. Personal communication.
6/ California only.
7/ Arizona only.
8/ Nitrofen is applied as either a preemergent and/or postemergent spray in sequence with linuron as either a preemergent and/or postemergent spray.
9/ Linuron and paraquat replace nitrofen in Florida, and linuron and/or mineral spirits replace nitrofen in Indiana, Michigan, Minnesota, Ohio, and Wisconsin.

Economic Impact Analysis

Production Cost Changes

Mineral Soils

Carrots are grown in mineral soils in Arizona and California. Approximately 36,000 acres were planted annually in these States between 1977-79, of which one-third were treated annually with nitrofen.

Carrot growers in Arizona and California apply nitrofen as a preemergence herbicide, usually in sequence with trifluralin (pre-plant incorporation) and/or linuron (postemergent spray)[1/]. The herbicide treatment cost for Arizona is $53.36 per acre and either $53.36 or $76.40 per acre in California (Table 2). Arizona growers typically supplement herbicide treatments with one to two mechanical cultivations per season.

If the use of nitrofen is restricted on carrots, growers would be compelled to apply an alternative herbicide such as linuron, (50WP),

---

1/ As shown in Table 2, trifluralin is not applied as a preplant herbicide on 2,000 acres in Arizona and 1,000 acres in California.

Table 2. Current Herbicide Costs per Acre for California and Arizona Carrots (Mineral Soils)1/

Herbicide	Timing	Application Rate (lb. of a.i. per acre)	Material Cost Per Lb. A.I. ($)	Material Cost Per Acre ($)	Application Cost Per Acre ($)	Total Cost Per Acre ($)
		With Nitrofen				
Arizona (2,000 acres), California (1,000 acres)2/						
nitrofen (2 EC)	preemergence	4.0	6.64	26.56	8.00	34.56
linuron (50 WP)	postemergence	1.0	10.80	10.80	8.00	18.80
	Total			37.36	16.00	53.36
California (9,000 acres)2/						
trifluralin (4 EC)	preplant incorporation	0.75	8.05	6.04	17.00	23.04
nitrofen (2 EC)	preemergence	4.0	6.64	26.56	8.00	34.56
linuron (2 EC)	postemergence	1.0	10.80	10.80	8.00	18.80
	Total			43.40	33.00	76.40
		Without Nitrofen				
California (10,000 acres), Arizona (2,000 acres)						
trifluralin (4EC)	preplant incorporation	0.75	8.05	6.04	17.00	23.04
linuron (50WP)	preemergence	1.0	10.80	10.80	8.00	18.80
linuron (50 WP)	postemergence	1.0	10.80	10.80	8.00	18.80
	Total			27.64	33.00	60.64

1/ USDA/EPA/States Assessment Team on Nirofen, 1980.

2/ The restriction of nitrofen on carrots would have little effect upon Kern County growers because it has been used sparingly in the past, therefore Kern County is excluded from the analysis.

mineral spirits, or chloroxuron 50WP[1]. Although not as effective as nitrofen, linuron is the most widely used alternate carrot herbicide because of its availability and low cost relative to other alternate herbicides[2]. Table 3 lists the comparison of weed control costs with linuron relative to nitrofen in Arizona and California. The cost impact comprises either a decreasse of $15.76 or an increasse of $7.28 per acre in the herbicide treatment cost and an additional mechanical cultivation at $15 per acre. As a consequence, the treatment cost for 2,000 acres in Arizona and 1,000 acres in California increases $22.28 per acre and decreases $0.76 per acre for 9,000 acres in California.

Muck Soils

Approximately 29,950 acres of carrots (1977-79 average) are grown on the muck soils of Florida, Michigan, Minnesota, Wisconsin, Ohio, and Indiana. Of this total acreage, about 19,950 acres (67 percent) would be treated with nitrofen if it remained on the market (USDA/EPA/States, 1980).

1/ The high cost of applying mineral spirits (i.e. $87.50 per acre) as well as pressure from the California Air Quality Board due to suspected environmental damage have deterred farmers from using mineral spirits on carrots. The use of chloroxuron is limited to growers associated with Basic Vegetable Products, Inc., a commercial vegetable processor.

2/ Harry Agamalian Farm Advisor (Weed Scientist) - Monterey County. Agricultural Extension Service, University of California, Salinas, California 93901. Personal communication.

Table 3. A Comparison of Current Weed Control Costs Per Acre for Arizona and California Mineral Soil Carrot Producers, With and Without Nitrofen

State	Herbicide Treatment Costs Per Acre 1/	Mechanical Cultivation Cost Per Acre	Total Cost Per Acre
		Dollars	
Arizona			
With nitrofen	53.36	15-30 2/	68.36- 83.36
Without nitrofen	60.64	30-45 3/	90.64-105.64
Difference			+22.28
California (excluding Kern County)			
With nitrofen	53.36 4/ -76.40 5/	0	53.36-76.40
Without nitrofen	60.45	15 6/	75.64
Difference			-.76 to +22.28

1/ Table 1.
2/ One to two mechanical cultivations per season at $15 per acre per time.
3/ Two to three mechanical cultivations per season at $15 per acre per time.
4/ Treatment cost increase per acre for 1,000 acres in California.
5/ Treatment cost increase for 9,000 acres in California.
6/ One mechanical cultivation per season at $15 per acre per time.

The typical weed control program for carrots grown on muck soils includes the use of herbicides at preemergence, medium postemergence, and at late postemergence (Florida carrot growers also add an herbicidal treatment at early postemergence). When nitrofen is used, the weed control program typically includes the use of linuron at preemergence and/or postemergence. The per acre cost of herbicide treatment varies from region to region (from about $48 to $59 in Michigan, Minnesota and Wisconsin to about $89 to $100 in Florida) due to differences in the rate and timing of the herbicidal applications (Table 4).

If nitrofen were unavailable for use, growers in Florida would substitute paraquat for nitrofen while growers in other states would substitute linuron or mineral spirits. The cost of alternative herbicide treatments is estimated to be about $65 in Florida and $46 to $92 in the other muck soil states (Table 5).

Along with herbicidal treatments, weed control programs using nitrofen on carrots typically include 1-2 mechanical cultivations, 1-2 spot hoeings, and about 6 irrigations per season. The use of alternative herbicides (which are considered less effective than nitrofen on certain types of weeds) usually requires growers to use an additional mechanical cultivation and spot hoeing operation in order to maintain adequate weed control. Along with these extra cultivations, the substitution of linuron for nitrofen usually requires an additional irrigation each season in order to stimulate linuron's herbicidal activity during dry weather. These additional cultivation operations increase the production costs for carrot growers changing from nitrofen to alternative herbicides.

Table 4. Current Weed Control Costs Per Acre for Muck Soil Carrots, with Nitrofen

Herbicide	Timing	Application Rate (lb. of a.i. per acre)	Material Cost/Lb. of A.I. ($)	Material Cost Per Acre ($)	Application Cost Per Acre ($)	Cost Per Acre ($)
Florida (14,000 treated acres)						
nitrofen	Preemergence	3	6.64	19.92	8.00	27.92
nitrofen	Early postemergence	4	6.64	26.56	8.00	34.56
linuron	Medium postemergence	.5-1	10.80	5.40-10.80	8.00	13.40-18.80
linuron	Late postemergence	.5-1	10.80	5.40-10.80	8.00	13.40-18.80
					Total	89.28-100.08
Michigan, Minnesota, Wisconsin (5,350 treated acres)						
linuron	Preemergence	1-2	10.80	10.80-21.60	8.00	18.80-29.60
-	Early postemergence	-	-	-	-	-
nitrofen	Medium postemergence	1	6.64	6.64	8.00	14.64
nitrofen	Late postemergence	1	6.64	6.64	8.00	14.64
					Total	48.08-58.88
Indiana, Ohio (600 treated acres)						
linuron	Preemergence	1-3	10.80	10.80-32.40	8.00	18.80-40.40
-	Early postemergence	-	-	-	-	-
nitrofen	Medium postemergence	3	6.64	19.92	8.00	27.92
linuron	Late postemergence	1-1.5	10.80	10.80-16.20	8.00	18.80-24.20
					Total	65.52-92.52

Source: USDA/EPA/States, 1980

Table 5. Current Weed Control Costs Per Acre for Muck Soil Carrots, without Nitrofen

Timing	Herbicide	Application Rate (lb. of a.i. per acre)	Material Cost/Lb. of A.I. ($)	Material Cost/Acre ($)	Application Cost/Acre ($)		Cost/Acre ($)
Florida (14000 treated acres)							
Preemergence	linuron	1	10.80	10.80	8.00		18.80
Early postemergence	paraquat	1 quart	11.00 (quart)	11.00	8.00		19.00
Medium postemergence	linuron	.5	10.80	5.40	8.00		13.40
Late postemergence	linuron	.5	10.80	5.40	8.00		13.40
						Total	64.60
Michigan, Minnesota, Wisconsin, Indiana and Ohio. (5950 treated acres)							
Preemergence	linuron	1	10.80	10.80	8.00		18.80
Early postemergence	-	-	-	-	-		-
Medium postemergence	linuron	.5	10.80	5.40	8.00		13.40
Late postemergence	linuron	.5	10.80	5.40	8.00		13.40
	or						
	mineral spirits	40 gallons	1.30	52.00	8.00		60.00
						Total	45.60* or 92.20**

* acreage substituting linuron for nitrofen (about 75% of treated acreage)
** acreage substituting mineral spirits for nitrofen (about 25% of the treated acreage)

Source: USDA/EPA/States, 1980

In Florida, the cost of alternative weed control programs would be about $37 to $47 per acre higher than weed control programs using nitrofen (Table 6). For the typical carrot grower in Florida with about 712 acres (USDA/EPA/States, 1980), the change from nitrofen to alternative controls would increase production costs by about $26,002 to $33,692 per year. The use of alternative herbicides on the 14,000 acres currently treated with nitrofen in Florida would mean an increase of about $511,280 to $662,480 in annual production costs.

In Michigan, Minnesota, and Wisconsin, alternative weed control programs on carrots would increase production costs by an estimated $50 to $61 per acre on the acreage substituting linuron for nitrofen (about 75 percent of the treated acreage). On the acreage using the more expensive mineral spirits in place of nitrofen (about 25 percent of the treated acreage) the per acre production costs would increase by about $97 to $108 per season (Table 6). For the average grower in this region who grows about 216 acres of carrots (USDA/EPA/States, 1980), the substitution of linuron for nitrofen on all acres would increase annual production costs by about $10,848 to $13,180. For growers substituting mineral spirits, the production costs would increase by about $20,913 to $23,246 per year. The use of alternative weed control practices on the 5,350 acres currently treated with nitrofen would increase production costs by a range of $331,004 to $388,808.

In Indiana and Ohio, the use of linuron in place of nitrofen would increase production costs by about $21 to $48 per acre (Table 6). Where mineral spirits are used in place of nitrofen, the production

with and without Nitrofen

States	Herbicide Treatment Cost Per Acre 1/ ($)	Mechanical Cultivation Cost Per Acre ($)	Spot Hoeing Cost Per Acre ($)	Irrigation Cost Per Acre ($)	Total Cost Per Acre ($)
Florida					
With Nitrofen	89.28-100.08	15.00-30.00	46.00- 92.00	66.00	216.28-288.08
Without Nitrofen	64.60	30.00-45.00	92.00-138.00	77.00	263.60-324.60
Difference					36.52-47.32
Michigan, Minnesota, Wisconsin					
With Nitrofen	48.08-58.88	15.00-30.00	37.50- 75.00	66.00	166-58-229.88
Without Nitrofen	45.60 or 92.20	30.00-45.00	75.00-112.50	77.00	227.60-280.10 or 274.20-326.70
Difference					50.22- 61.02* or 96.82-107.62**
Indiana, Ohio					
With Nitrofen	65.52-92.52	15.00-30.00	41.60- 83.20	66.00	188.12-271.72
Without Nitrofen	45.60 or 92.20	30.00-45.00	83.20-124.80	77.00	235.80-292.40 or 282.40-339.00
Difference					20.68-47.68* or 67.28-94.28**

1/ See Tables 4 and 5.
* Acreage substituting linuron for nitrofen (about 75% of treated acreage).
** Acreage substituting mineral spirits for nitrofen (about 25% of the treated acreage).

Sources: USDA/EPA/States, 1980.

costs would increase by $67 to $94 per acre. The annual production costs for the average size grower in these states (about 53 acres) (USDA/EPA/States, 1980) would increase by about $1,096 to $2,527 where linuron is used and by about $3,566 to $4,997 where mineral spirits are used. The use of alternative weed control programs on the 600 acres of carrots currently treated with nitrofen in these states would increase production costs by about $19,398 to $35,598 per year.

Budgets for carrots grown in the various muck soil states were not readily available for this analysis. However, if carrot production costs in these states are comparable to those estimated for California's Imperial Valley (University of California, 1980), the use of alternative herbicides would increase production costs by about 1-4 percent. The total increase in production costs for all of the affected acreage would range from about $922 thousand to $1.1 million per year (Table 7.)

Impact on Output and Revenue

In addition to increased production costs, carrot growers using alternative herbicides would also incur an estimated 10 percent yield loss on the impacted acreage (USDA/EPA/States, 1980). Yield losses on the impacted acreage would reduce the output of carrots by about 991,665 cwt. per year (Table 8), a reduction of nearly 5 percent in the current U.S. annual production of 19,853,333 cwt. (1977-79 average). This short run reduction in carrot output would represent an economic loss to society since more of society's resources would be expended in

Table 7. Total Production Cost Increases f[illegible] U.S. Carrot Producers Without Nitrofen

States	Acres Treated 1/	Cost C[illegible]nge Per Acre 2/ ($)	Net Cost Increase ($)
California, Arizona	12,000	-.7[illegible] to +22.28	60,000
Florida	14,000	+36.5[illegible] to 47.32	511,280 - 622,480
Michigan, Minnesota, Wisconsin	5,350	+50.2[illegible] to 61.02 or +96.8[illegible] to 107.62	331,004 - 388,784
Indiana, Ohio	600	+20.6[illegible] to 47.68 or +67.2[illegible] to 94.28	19,398 - 35,598
Total	31,950		921,682 - 1,106,862

1/ USDA/EPA/States. 1980.
2/ See Tables 3 and 6.

Table 8. Estimated Reduction of Carrot Output Resulting from a 10 Percent Yield Loss on Nitrofen Treated Acreage

States(s)	Treated Acres	1977-79 Avg. Yield/Acre 1/ (cwt)	10 Percent Yield Reduction/Acre 2/ (cwt)	Total Output Reduction (cwt)
Calif., Ariz.	12,000	266	26.6	319,200
Florida	14,000	335 3/	33.5	469,000
Mich., Minn. and Wisc.	5,350	335	33.5	179,225
Ohio, Ind.	600	404	40.4	24,240
Total	31,950			991,665

1/ USDA, Vegetables. 1979 Annual Summary, 1980.
2/ USDA/EPA/States, 1980.
3/ Yield estimate for Florida based on average yield of other 3 areas.

the production of fewer outputs. At the grower level, the value of this output loss would be about $6,961,000 per year (assuming a grower price of about $7.02 per cwt. (1977-79 weighted average) and a 991,665 cwt. reduction in annual output).

The impact of this short run reduction in output on market prices may be estimted through an analysis of price elasticity of demand at the grower level (assuming the supply curve is perfectly inelastic in the short run). Although specific estimates of the demand price elasticities for fresh and processed carrots are currently unavailable, past market studies of demand for farm products suggest that the demand for most commodities at the farm level is relatively inelastic (Western Extension Marketing Committee, 1967). At the farm level, buyers tend to respond to reductions in supply by bidding up the market price at a rate that is higher than the rate of output reduction. The relative inelasticity of demand for Brussels sprouts and other vegetables may be explained by the fact that these commodities have few good substitutes and their purchase constitutes a small part of the consumers' overall budget.

Studies of demand for vegetable crops such as cabbage, carrots, celery, tomatoes, and peppers have provided estimates of price elasticity at the farm level ranging from -.45 to 1.03 (Brandow, 1961; Waugh, 1964; Shafer, 1965). Based on these estimates of elasticity, this analysis has assumed that the farm level elasticity of demand for fresh and processed carrots falls within the range of -.5 and -1.0.

Under those assumptions, the estimated yield reduction on the impacted acreage (991,665) cwt.) would cause grower prices to increase by about $.35 to $.70 per cwt. (Table 9). For the impacted growers, this price increase would not be sufficiently high to offset revenue losses due to reduced production. Affected growers would incur a loss of revenue estimated at about $714 thousand to $3.8 million per year (Table 10).

In the short run, the net economic loss (in terms of increased production costs and revenue losses) to affected growers is estimated to range from about $1.6 to $4.9 million per year (Table 11). For the unaffected growers, the $.35 to $.70 per cwt. increase in price would increase short term annual revenue by approximately $3.9 to $7.9 million. During the first year after a nitrofen suspension, the overall economic impact on the carrot industry (impacted and nonimpacted growers) would range from a net loss of about $1 million (if price rose by $.35 per cwt.) to a net gain of about $6.3 million (if price rose by $.70 per cwt.).

The short term increase in carrot prices would be an incentive for growers in unaffected areas to either begin or expand production. In the long run, this increased production would reduce farm prices from the initial impact level. Without the development of biological and cost effective weed controls, some of the impacted growers would be expected to reallocate their land to other crops less affected by a nitrofen suspension.

Table 9. Estimated Change in Grower Prices Resulting from a Reduction of Carrot Production

Elasticity 1/ (E)	Carrot Production 2/ (Q) cwt	Reduced Carrot Production 3/ (ΔQ) cwt	Industry Price/cwt 4/ (P) $	Expected Price Change 5/ (ΔP) $
-.5	19,853,333	991,665	7.02	+ .70
-1.0	19,853,333	991,665	7.02	+ .35

1/ Elasticity is assumed to range between -.5 and -1.0, based on past studies of demand for farm products.
2/ 1977-79 average.
3/ Output reduction resulting from 10% yield reduction on affected acreage (Table 8).
4/ 1977-79 weighted average.
5/ Calculated from the equation:

$$\text{Elasticity of Demand} = -\frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$$

Sources: USDA, Vegetables 1979 Annual Summary, June 1980.
EPA Estimates.

Table 10. Estimated Revenue Loss for U.S. Carrot Growers Substituting Alternative Herbicides for Nitrofen

Herbicide Program	Treated Acreage	Output (cwt)	Price/cwt ($)	Revenue ($)
With nitrofen	31,950	9,916,650 1/	7.02 2/	69,614,883
Without nitrofen	31,950	8,924,985 3/	7.37-7.72 4/	65,777,139-68,900,884
			Revenue Loss:	713,999 - 3,837,744

1/ 1977-79 average output per acre X 31,950 treated acres.
2/ 1977-79 weighted average price.
3/ Output on affected acreage reduced by 10 percent (USDA/EPA/States, 1980).
4/ Estimated price range when elasticity of demand ranges between .5 and 1 and short run supply assumed to be perfectly inelastic (Table 9).

Source: USDA Vegetables 1979 Summary, June 1980.
USDA/EPA/States, 1980

Table 11. Economic Impact of a Nitrofen Cancellaton on U.S. Carrot Growers (1980)

Nitrofen Treated Acres	Increased Production Costs to Impacted Growers ($000) 1/	Revenue Loss to Impacted Growers ($000) 2/	Farm Income Loss to Impacted Growers ($000) 3/	Earned Income Gain to Non-impacted Growers ($000) 4/	Change in Industry Farm Income ($000)
31,950	921.7-1,106.9	714-3,837.7	1,635.7-4,944.6	3,944.4-7,888.7	-1000.2 to +6,253

1/ Table 7.
2/ Table 10.
3/ Increased production costs and revenue loss.
4/ Assuming 41,910 nontreated harvested acres (1977-79 Avg. number of acres harvested (73,860 acres) less 31,950 treated acres), yield of 268.9 cwt. per acre (1977-79 weighted avg.), and price increase of .35 to $.70 per cwt.

Market and Consumer Impacts

The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of carrots by about 991,655 cwt., about 5 percent of the 1977-79 average industry output (USDA, 1980). This short run reduction of output would be expected to have a relatively small impact on prices at the retail level. If all of the estimated increase in grower prices ($.35 to $.70 per cwt.) were passed on to consumers, retail prices would rise by less than 1 cent per pound. Since grower prices for fresh and processed vegetables account for only about 20 to 30 percent of final retail prices (USDA, 1979), a $.35 to $.70 per cwt. increase in grower prices would result in an increase of about 1 to 3 percent in final retail prices.

In the short run, the reduced supply and slightly higher retail prices would cause some consumers to substitute other vegetables for their current purchases of carrots. In the long run, higher grower prices would stimulate new and expanded production which would increase the output of carrots and reduce the initial impact on retail prices and supply.

Social/Community Impact

Although data limitations prevent an in-depth evaluation of the social and community impacts of nitrofen suspension, several potential impacts may be noted:

1. Additional hoeing operations and mechanical cultivations required by alternative weed control programs used on carrots would require additional field labor. The increased demand for field labor may serve to bid up the wages for field labor. In some areas there may be shortages of field labor.

2. The decision of some affected growers to reallocate their land to other crops may lead to an increased demand for new farm equipment or other factors of production.

3. The short run reduction of carrot production (due to yield reductions on the affected acreage) may cause some local carrot processors to operate at a less than optimum level of output. In some cases, processors may need to search out new, more distant supply outlets for carrots or reinvest in new machinery capable of processing alternative crops.

Limitations of Analysis

1. There are insufficient biological and economic data for long run estimates of potential crop shifts following nitrofen suspension.

2. This analysis assumes that adequate supplies of labor for additional hoeing operations and mechanical cultivations are available for the alternative weed control programs used on carrots.

3. The price of field labor is assumed to remain constant in the short run, at $7.50 per hour.

4. Data on the elasticity of demand for fresh and processed carrots are currently unavailable. This analysis assumes a price elasticity ranging beween -.5 and -1.0.

5. Budget information for carrot production is not available for some of the affected areas.

6. The estimates of yield losses, and changes in production practices are based on experience of weed science specialists and not on field data.

References

Brandow, G.E. Interrelations Among Demands for Farm Products and Implications for Control of Market Supply. The Pennsylvania State University. Agricultural Experiment Station. Bulletin 680. August 1961.

Rowe, Gordon and Barbara Albertson. Tok (Nitrofen), Cultural practices for Crops, Economic Impacts (Draft). Cooperative Extension. University of California. Berkeley, California. July, 1980.

Shafer, Carl E. A Preliminary Analysis of Price and Demand Relationships for South Texas Winter Carrots. Texas A&M University. Dept. of Agricultural Economics. Inf. Report 65-1. 1965.

U.S. Department of Agriculture. Market Basket Statistics, ESCS. Washington, D.C. 1979.

U.S. Department of Agriculture. Vegetables - 1979 Annual Summary, Acreage Yield, Production, and Value. ESCS. Crop Reporting Board. Washington, D.C. June, 1980.

U.S. Environmental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. July 1980.

U.S. Department of Agriculture. U.S. Environmental Protection Agency and State Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen. Washington, D.C. 1980.

University of California. Cost and Returns Summary for Carrots (Imperial County). Cooperative Extension Budget Generator. Davis, California. 1980.

Waugh, Frederick V.. Demand and Price Analysis. USDA. Econ. Res. Ser. Technical Bulletin No. 1316. Washington, D. C. November 1964.

Western Extension Marketing Committee. A Handbook on the Elasticity of Demand for Agricultural Products in the United States. EMC Publication No. 4. July, 1967.

Preliminary Benefit Analysis of Nitrofen Use on Cauliflower

Introduction

Cauliflower is grown primarily in California and New York. Between 1977-79, approximately 36,000 acres were planted annually in these States accounting for 86 percent of the total U.S. planted acreage for each growing season (Table 1). The entire cauliflower acreage planted each year in California and New York is treated with a postemergent herbicide to control a variety of broadleaf weeds and grasses. 1/ Nitrofen in a wettable powder form is commonly used at a rate of four pounds of active ingredient per acre to control cheeseweed, goosefoot, knotwood, morning glory, nettle, nightsh~~ock~~ade, pigweed, and purslane. One application applied with ground equipment is usually sufficient to control weeds on cauliflower.

The following postemergent herbicides are EPA registered alternatives to nitrofen for use on cauliflower: DCPA, sulfallate, and trifluralin. The use of alternate cauliflower herbicides results in a change in cultural practices [i.e. an increase in preharvest production costs, and a decrease in grower revenue].

Use of Nitrofen and Alternatives

Cauliflower ~~Califlower~~ acreage in California and New York (i.e. 32, 534 and 3, 434, respectively) is treated with nitrofen each growing season (Table 1). Nitrofen is applied at a rate of four pounds of active ingredient per acre, therefore 143,872 pounds of nitrofen were annually applied on cauliflower in California and New York between 1977-79. Approximately one-half of the acreage in each State is direct seeded and the other one-half transplanted each growing season.

1/ A small portion of the cauliflower acreage in the remaining producing States, Arizona, Michigan, Oregon, and Texas, is treated with nitrofen.

Table 1. Annual cauliflower production for fresh market and processing in California and New York for 1977-79. 1/

State	Acres planted	Yield per acre	Total production	Value	
				Per cwt	Total
		Cwt	1,000 cwt	Dollars	1,000 dollars
California	32,534 2/	95	3,067	21.90	66,919
New York	3,434 3/	97	313	18.70	5,864
Total	35,968	95	3,380	21.60	72,783
U.S. figures	41,620	96	3,900	20.83	81,393
Percent of U.S. figures	86		87		89

1/ Vegetables, 1979 Annual Summary. USDA/ESS, Crop Reporting Board. June 6, 1980.

2/ The total acreage in California is treated with nitrofen each growing season.

3/ The total acreage in New York is treated with nitrofen each growing season.

Nitrofen is used as a postemergent herbicide on direct seeded and transplanted cauliflower acreage. Without nitrofen, direct seed growes could use either DCPA plus sulfallate on DCPA with one additional cultivation, two additional appliction of hand labor, and three additional hours of thinning. Transplant growers could use either trifluralin, DCPA plus sulfallate, or DCPA with one additional cultivation and two additional applications of hand labor.

Production Cost Impact

Table 2 lists the total treatment cost per acre for nitrofen and the three alternate herbicides registered for cauliflower in California and New York. One option available to growers is to apply DCPA and sulfallate in sequence at a cost of $109.53 per acre. The other two options are trifluralin and DCPA at a cost of $20.97 and $80.45 per acre, respectively.

Table 3 and 4 lists the production cost increases associated with a change in cultural practices for each alternative cauliflower herbicide in California and New York. The production cost increase per acre varies for California and New York due to a difference in farm labor costs and planting strategies implemented. About one-half of the cauliflower acreage in both States is planted by the direct seed method which requires seed planting to inhibit weed growth and extra thinning. Cauliflower is transplanted on the remaining acreage eliminating the need for increased seed planting and thinning.

One additional cultivation at $12 per acre is required for all herbicide alternatives to control weeds on cauliflower. An additional 30 hours of hand labor per acre at $7.50 per hour in California and $4.50 per hour in New York is necessary for all three herbicide options. An increase in

Table 2. Registered herbicides for treatment of broadleaf weeds and grasses on cauliflower in California and New York. 1/

Herbicide	Application rate per acre	Cost per pound a.i.	Material cost per acre	Application cost per acre	Total cost per acre
	Pounds a.i.	Dollars			
Nitrofen 50WP	4.0	5.00	20.00	8.00	28.00
Trifluralin 4 EC	0.5	7.94	3.97	17.00	20.97
DCPA 75 WP	9.0	8.05	72.45	8.00	80.45
Sulfallate 4 EC	4.0	5.27	21.08	8.00	29.08

1/ USDA/EPA/State Nitrofen Assessment Team Report, 1980, Draft. 1980.

thinning at the same labor costs mentioned above is necessary on direct seeded cauliflower acreage due to increased seeding. When trifluralin is used, an extra one and one-half hours are necessary and when DCPA or DCPA plus sulfallate are used an additional three hours are required. Production costs increase 25 percent (i.e. $850 per acre) as a result of a crop quality loss incurred when using any of the alternate herbicides. This loss is due to a decrease in field labor efficiency during the harvest period because of increased weed populations. 2/ A $50 per acre planting cost increase for five ounces of seed is realized on direct seed acreage. Accounting for these individual cost increments, the total production cost impact for the herbicide options falls between $1,112.95 and $1,241.03 per acre on direct seeded acreage (Table 3) and between $989.97 to $1,168.53 per acre on transplanted acreage (Table 4). The cost impact for transplanted acreage is two percent less than the impact for direct seeded acreage for each alternate herbicide because of the smaller change in cultural practices; primarily planting and thinning practices.

Production costs increase 34-40 percent per acre in California to control weeds on cauliflower with alternate herbicides relative to nitrofen. 3/ No cauliflower budget data were available for New York, therefore a cost percentage increase could not be computed.

2/ 425 cartons per acre x $8 per carton = $3400 market value per acre.
$3400 x .25 = $850 crop quality loss per acre.

3/ Sample Costs to Produce Cauliflower - Summer Harvest, Tenant-Landowner Basis For Monterey County, 1979 costs, #208, USDA/ESS/NED, Davis, California 95616.

Table 3. Impacted production costs per acre for direct seeded acreage in California and New York

State, impacted costs	Nitrofen	Alternative herbicides: DCPA plus sulfallate	Alternative herbicides: DCPA
	Dollars		
California			
Herbicide 1/	28.00	109.53	80.45
Cultivation 2/	60.00	72.00	72.00
Hand labor 3/	112.50	337.50	337.50
Thinning 4/	0	22.50	22.50
Crop quality loss 5/	0	850.00	850.00
Planting 6/	160.00	210.00	210.00
Total	360.50	1,601.53	1,572.45
Difference		1,241.03	1,211.95
New York			
Herbicide	28.00	109.53	80.45
Cultivation	60.00	72.00	72.00
Hand labor	67.50	202.50	202.50
Thinning	0	13.50	13.50
Crop quality loss	0	850.00	850.00
Planting	160.00	210.00	210.00
Total	315.50	1,457.53	1,428.45
Difference		1,142.03	1,112.95

1/ Table 2.
2/ One additional cultivation for all alternatives at $12 per acre.
3/ Two additional applications of hand labor for all alternatives at 15 hours each application for $7.50 per hour in California and $4.50 per hour in New York.
4/ Three additional hours of tinning on direct seeded acreage at $7.50 per hour in California and $4.50 per hour in New York.
5/ Crop quality loss is due to lower labor efficiency. The production cost increase represents 25 percent of the market value of the crop per acre (i.e. 425 cartons per acre x $8.00 per carton = $3400, $3400 x .2 = $850 per acre).
6/ Seeding rate increased five ounces per acre on direct seeded acreage at an additional cost of $50 per acre.

Table 4. Impacted production costs per acre for transplanted acreage in California and New York.

State, impact costs	Nitrofen	Trifluralin	DCPA plus sulfallate	DCPA
		Alternative herbicides		
	Dollars			
California				
Herbicide 1/	28.00	20.97	109.53	80.45
Cultivation 2/	60.00	72.00	72.00	72.00
Hand labor 3/	112.50	337.50	337.50	337.50
Crop quality loss 4/	0	850.00	850.00	850.00
Total	200.50	1,280.47	1,369.03	1,339.95
Difference		1,079.97	1,168.53	1,139.45
New York				
Herbicide	28.00	20.97	109.53	80.45
Cultivation	60.00	72.00	72.00	72.00
Hand labor	67.50	202.50	202.50	202.50
Crop quality loss	0	850.00	850.00	850.00
Total	155.50	1,145.47	1,234.03	1,204.95
Difference		989.97	1,078.53	1,049.45

1/ Table 2.
2/ One additional cultivation for all alternatives at $12 per acre.
3/ Two additional applications of hand labor for all alternatives at 15 hours each application for $7.50 per hour in California and $4.50 per hour in New York.
4/ Crop quality lose is due to lower labor efficiency. The production cost increase represents 25 percent of the market value of the crop per acre (i.e. 425 cartons per acre x $8.00 per carton = $3400, $3400 x .25 = $850 per acre).

Table 5.--Estimated Change in California Prices at the Farm Level Resulting from a Reduction in Output

Average annual U.S. production between 1977-79 1/	Reduction in output associated with the restriction of nitrofen 2/	Average annual price per cwt. 1/	Elasticity 3/	Estimated price increase per cwt.
cwt.	cwt.	Dollars		Dollars
3,900,333	582,055	20.83	-0.2	15.52
			-0.6	5.17
			-1.0	3.10

1/ Table 1.

2/ A 20 percent yield loss is incurred on acreage treated with either sulfallate or DCPA plus sulfallate (70 percent) and a 10 percent yield loss is realized on acreage treated with DCPA (30 percent). The average yield in California is 9,500 pounds per acre, therefore the yield loss is 1,900 pounds per acre on 70 percent of the acreage and 950 pounds per acre on 30 percent of the acreage. Likewise, in New York the average yield is 9,700 pounds per acre, therefore the yield loss is 1,940 pounds per acre on 70 percent of the acreage and 970 pounds per acre on 30 percent of the acreage. The total treated acreage is 32,534 acres in California and 3,434 acres in New York, therefore:

California -	22,774	x 19	=	432,706
	9,760	x 9.5	=	92,720
New York -	2,404	x 19.4	=	46,638
	1,030	x 9.7	=	9,991
				582,055

3/ Strength-of-Demand for 120 Market Categories of Food, 1957-61. University of California, Agricultural Extension Service, April 1963.

Yield and Revenue Impact

In addition to an increase in production costs, the use of alternate herbicides relative to nitrofen for cauliflower weed control may result in a yield reduction on the impacted acreage. A 20 percent yield loss per acre is realized when either trifluralin or DCPA plus sulfallate is substituted for nitrofen and a 10 percent yield loss per acre is incurred when DCPA is used. 4/

Based upon a price elastricity of demand at the farm level between -0.2 and -1.0, gross revenue increases substantially in the short-run. the estimated price increase falls in a range between $3.10 - $15.52 per hundred weight for the price elasticity range above (Table 5). As the elasticity of demand approaches -0.2 (i.e. becomes more inelastic) the impact upon the farm value of cauliflower increases significantly.

Tables 6 and 7 list the net economic impact upon cauliflower growers in California and New York. Assuming a price elasticity of -0.2, cauliflower growers could realize an increase in net revenue, whereas if the price elasticity is either -0.6 or -1.0 growers could incur a reduction in net revenue because the increase in production costs exceeds the increase in gross revenue. In general, growers who transplant receive a greater net return relative to those who seed directly because the impact upon cultural practices (i.e. production costs) for the former group is less than the impact for the latter. Also, New York growers receive a larger net return than California growers due to lower labor costs.

In the short-run, the total economic impact upon cauliflower growers

---

4/ USDA/EPA/State Nitrofen Assessment team Report, 1980, Draft. 1980.

Table 6. Net Economic Impact Associated with Restricting the Use of Nitrofen on Cauliflower in California

Herbicide elasticity	Net economic impact per cwt. Production cost increase 1/	Gross revenue increase 2/	Difference	Net gain or (loss) per acre 3/	Total net gain or (loss) 4/
	Dollars				
	California - Direct Seed				
DCPA plus sulfallate					
-0.2	13.06	15.52	2.46	233.70	1,891,334
-0.6	13.06	5.17	(7.89)	(749.55)	(6,066,108)
-1.0	13.06	3.10	(9.96)	(946.20)	(7,657,597)
DCPA					
-0.2	12.76	15.52	2.76	262.20	1,272,981
-0.6	12.76	5.17	(7.59)	(721.05)	(3,500,698)
-1.0	12.76	3.10	(9.66)	(917.70)	(4,455,434)
	California - Transplant				
Trifluralin					
-0.2	11.32	15.52	4.15	394.25	2,565,385
-0.6	11.32	5.17	(6.20)	(589.00)	(3,832,623)
-1.0	11.32	3.10	(8.27)	(785.65)	(5,112,225)
DCPA plus sulfallate					
-0.2	12.30	15.52	3.22	305.90	2,475,649
-0.6	12.30	5.17	(7.13)	(677.35)	(5,481,794)
-1.0	12.30	3.10	(9.20)	(874.00)	(7,073,282)
DCPA					
-0.2	11.99	15.52	3.53	335.35	1,628,124
-0.6	11.99	5.17	(6.82)	(647.90)	(3,145,555)
-1.0	11.99	3.10	(8.89)	(844.55)	(4,100,290)

1/ Tables 3 and 4.
2/ Table 5.
3/ Each figure in the preceeding column was multiplied by 95, the average yield per acre, in order to derive the net impact per acre.
4/ Each figure in the preceeding column was multiplied by the expected number of acres treated for the corresponding alternate herbicide: trifluralin, 6,507; DCPA plus sulfallate, 8,093; and DCPA, 4,855.

Table 7. Net Economic Impact Associated with Restricting the Use of Nitrofen on Cauliflower in New York

Herbicide elasticity	Net economic impact per cwt. Production cost increase 1/	Gross revenue increase 2/	Difference	Net gain or (loss) per acre 3/	Total net gain or (loss) 4/
	Dollars				
			New York - Direct Seed		
DCPA plus sulfallate					
-0.2	11.77	15.52	3.75	363.75	327,011
-0.6	11.77	5.17	(6.60)	(640.20)	(575,540)
-1.0	11.77	3.10	(8.67)	(840.99)	(756,050)
DCPA					
-0.2	11.47	15.52	4.05	392.85	212,139
-0.6	11.47	5.17	(6.30)	(611.10)	(329,994)
-1.0	11.47	3.10	(8.37)	(811.89)	(438,421)
			New York - Transplant		
Trifluralin					
-0.2	10.21	15.52	5.31	515.07	353,853
-0.6	10.21	5.17	(5.04)	(488.88)	(335,861)
-1.0	10.21	3.10	(7.11)	(689.67)	(473,803)
DCPA plus sulfallate					
-0.2	11.12	15.52	4.40	426.80	383,693
-0.6	11.12	5.17	(5.95)	(577.15)	(518,858)
-1.0	11.12	3.10	(8.02)	(777.94)	(699,368)
DCPA					
-0.2	10.82	15.52	4.70	445.90	246,186
-0.6	10.82	5.17	(5.65)	(548.05)	(295,947)
-1.0	10.82	3.10	(7.72)	(748.84)	(404,374)

1/ Tables 3 and 4.
2/ Table 5.
3/ Each figure in the preceeding column was multiplied by 97, the average yield per acre, in order to derive the net impact per acre.
4/ Each figure in the preceeding column was multiplied by the expected number of acres treated for the corresponding alternate herbicide: trifluralin, 687; DCPA plus sulfallate, 899; and DCPA, 540.

varies significantly within the price elasticity range utilized in this analysis. Assuming a price elasticity of -0.2, impacted growers could increase net revenue by $11.4 million because the increase in gross revenue exceeds the increase in gross revenue exceeds the increase in production costs. On the other hand, impacted production costs exceed gross revenue when the price elasticity is either -0.6 or -1.0 (Table 8). The total net revenue loss under these circumstances could fall in a range between $24.1 - $31.2 million (Table 8).

The total net impact for U.S. cauliflower growers resulting from restricting the use of nitrofen on cauliflower includes the impact upon California and New York growers, mentioned above, and the non-user impact for growers in the remaining producing States. The non-user impact represents an increase in total revenue between $1.7 - 8.4 million (Table 9). Assuming a price elasticity of -0.2, the total net impact for U.S. cauliflower growers represents a revenue increase of $19.8 million, whereas assuming a price elasticity of -0.6 or -1.0 the impact represents a revenue decrease of $21.3 to $29.5 million, respectively (Table 9).

In the long-run, increased cauliflower prodution may apply downward pressure upon cauliflower prices assuming that the price elasticity is -0.2. Assuming a price elasticity of either -0.6 or -1.0, cauliflower production in unaffected areas may increase supply placing further financial pressure upon impacted growers. As a consequence, alternate weed control programs may be developed to alleviate impacted growers in California and New York.

Table 8. Total Economic Impact upon Cauliflower Growers in California and New York of Restricting the Use of Nitrofen for Three Elasticity Levels

Planting strategy elasticity	Total net gain or (loss)			
	Trifluralin 1/	DCPA plus sulfallate 1/	DCPA 1/	Total
	Dollars			
			California	
Direct seed				
-0.2	--	1,891,334	1,272,981	3,164,315
-0.6	--	(6,066,108)	(3,500,698)	(9,566,806)
-1.0	--	(7,657,597)	(4,455,433)	(12,113,030)
Transplant				
-0.2	2,565,385	2,475,649	1,628,124	6,669,158
-0.6	(3,832,623)	(5,481,794)	(3,145,555)	(12,459,972)
-1.0	(5,112,225)	(7,073,282)	(4,100,290)	(16,285,797)
			New York	
Direct seed				
-0.2	--	327,011	212,139	539,150
-0.6	--	(575,540)	(329,994)	(905,534)
-1.0	--	(756,050)	(438,421)	(1,194,471)
Transplant				
-0.2	353,853	383,693	246,186	983,732
-0.6	(335,861)	(581,858)	(295,947)	(1,150,666)
-1.0	(473,803)	(699,368)	(404,374)	(1,577,545)
			Total	
-0.2				11,356,355
-0.6				(24,082,978)
-1.0				(31,170,843)

1/ Tables 6 and 7.

Table 9. Total Economic Impact upon U.S. Cauliflower Growers of Restricting the Use of Nitrofen for Three Elasticity Levels

n price sticity	Revenue increase per cwt. 1/	Revenue increase per acre 2/	Non-user gain 3/	User gain or (loss) 4/	Total gain or (loss)
	Dollars				
-0.2	15.52	1,489.92	8,421,028	11,356,355	19,777,383
-0.6	5.17	496.32	2,805,201	(24,082,978)	(22,277,777)
-1.0	3.10	297.60	1,682,035	(31,170,843)	(29,488,808)

Table 5.
Each figure in the preceeding column was multiplied by 96, the average U.S. yield per acre, i order to derive the revenue increase per acre.
Each figure in the preceeding column was multiplied by 5,652, the remaining number of acres grown in the United States, in order to derive the net non-user impact.
Table 2.

and packers may be impacted dramatically during the winter season. Growers could be compelled to shift production to another crucifer crop such as broccoli, brussel sprouts, or cabbage provided they are not constrained by fixed costs. Many growers own the packing equipment used to prepare cauliflower for fresh market also, other growers are committed to long-term rental contracts for land. Due to the high net return associated with cauliflower produc~~P)mn~~ tion, rental costs are substantial. As a result, some cauliflower ~~groWd's~~ growers may not have the flexibility to shift production to other vegetable crops, consequently may have to continue growing cauliflower at a lower net return ~~dur)lg~~ during the ~~w)lter~~ winter season. 5/

The increased demand for farm labor resulting from the change in cultural practices may provide employment opportunities for farm workers in the impacted areas. The impact upon wage rates would be influenced by the maynitude of the labor pool available and the employment outlook in these areas.

Limitations of Analysis

The following assumptions were made to conduct this analysis:

1. The biological data used in the analysis were provided by USDA and State biological personnel. The data accuratly reflects the impact upon cauliflower cultural practices and production.

2. Pesticide material, pesticide application, and labor costs remain constant in the analysis.

3. The farm price elasticity range (i.e. -0.2 to -1.0), developed in 1963, is relevant for current market analysis.

4. The supply of farm laborers is readily available to cauliflowe growers in Calfornia ard New York.

5/ D. Ririe, Farm Advisor-Monterey County. Agricultural Ex~~Tdns)mJ Serdice~~, University of California, Salinas, California 93901. Personal communication - December 4, 1980.

References

1. Blacich, O.P., Agricultural Economist. Strength-of-Demand For 120 Market Categories of Food, 1957-61. Agricultural Extension Service, University of California. April 1963.

2. Ririe, D., Farm Advisor-Monterey County. Agricultural Extension Service, University of California, Salinas, California 93901. Personal communication - December 4, 1980.

3. USDA/EPA/States Nitroden Assessment Team Report, 1980, Draft. 1980.

4. USDA/ESS, Crop Reporting Board. Vegetable, 1979 Annual Summary. June 6, 1980.

5. USDA/ESS/NED. Sample Costs to Produce Cauliflower - Summer Harvest, Tenant-Landowner Basis For Monterey County, 1979 Costs, #208. Davis, California 95616. 1980.

Preliminary Benefit Analysis of Nitrofen Use on Celery

Current Use Analysis

EPA Registration of Nitrofen and Alternatives

Nitrofen, formulated as either an emulsifiable concentrate (25 percent active ingredient) or as a wettable powder (50 percent active ingredient), is registered for use on celery to control a variety of weeds including: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, and spergularia. One preemergent spray application of 4 lbs. a.i. per acre mixed with 40 to 60 gallons of water is the labeled rate per acre for mineral soils, and one early postemergent spray application of 5 lbs a.i. per acre mixed with 40 to 60 gallons of water is the labeled rate for muck soils. (USDA/USEPA/States, 1980).

The major alternative herbicides registered for weed control in celery are linuron, prometryne, prometryne plus other herbicides, and trifluralin but these herbicides do not control the same broad spectrum of weeds as nitrofen. For example, linuron does not control bluegrass, malva, nightshade, nettle, shepherdspurse, or spergularia. (USDA/USEPA/States, 1980).

Use of Nitrofen and Alternatives

In the United States, celery is planted on about 13,967 acres of muck soils and on 22,131 acres of mineral soils. All of the celery grown on muck soils in Florida (about 11,367 acres) and Michigan (2,600 acres) were annually treated with nitrofen during 1977-1979. About 66 percent (14,758 acres) of the celery grown on the mineral soils in California, Washington, New York, and Ohio were treated with nitrofen. The total amount of nitrofen used on celery is estimated to be about 128,867 pounds active ingredient per year (USDA/USEPA/States, 1980).

The typical nitrofen weed control program for celery is a preemergence application (average 4 lbs. a.i. per acre) used in sequence with other herbicides. For muck soil, one postemergence application (average 5 lbs. a.i. per acre) of nitrofen used in sequence with other herbicides (USDA/USEPA, 1980).

Without nitrofen, weed control programs would use either linuron or prometryne with 1-2 additional cultivations and hand weedings on muck soil. On the mineral soils of New York, Washington, and Ohio; nitrofen can be replaced by trifluralin and 4 additional cultivations. In California, prometryne, prometryne plus chloroxuron, prometryne plus chloroxuron and mineral spirits, or chloroxuron alone will be used with 2 more cultivations and handweedings (Table 1).

Table 1. Use of Current Nitrofen and Alternative Weed Control Programs on Celery in the U.S. a/

Type of soil and state	Weed control program	Treated acres	Application rate (lbs.a.i./acre)	Total quantity used (lbs.a.i.)	Additional cultivations	Additional hand weedings	Yield/ quality reduction
Current Nitrofen Programs							
Mineral Soil	Nitrofen	14,758	4	59,032	-	-	-
Muck Soil	Nitrofen	13,967	5	69,835	-	-	-
Total		28,725	4.5	128,867			
Alternatives Programs							
Mineral Soil							
Calif. (1)	Prometryne	5,348	2	10,696	2	2	$1,125/acre b/
Calif. (2)	Prometryne plus Chloroxuron	6,685	2+ 2	13,370 13,370	2	2	$1,125/acre b/
Calif. (3)	Prometryne plus Chloroxuron and Mineral Spirits	1,337	2+ 2+ 60 gal.	2,674 2,674 80,220 gal.	2	2	$1,125/acre b/
Calif. (4)	Chloroxuron	704	2	1,408	2	2	25%
Other States	Trifluralin	684	.5	342	4	-	15%
Muck Soil							
Florida (1)	Prometryne	2,273	2	4,546	1	1	0
Florida (2)	Linuron	9,094	1	9,094	1	1	0
Michigan (1)	Prometryne	2,340	2	2,340	2	2	10%
Michigan (2)	Linuron	260	1	520	2	2	10%

a/ Source: USDA/EPA/States, 1980.
b/ Quality loss $1.25/carton at 900 carton/acre for 95 percent of California's impacted celery acreage.

Farm Impacts

Production Cost Changes

Mineral Soils (California, New York, Ohio, and Washington)

Approximately 22,318 acres of celery are grown on mineral soils of California, New York, Ohio, and Washington (Table 3). About 66 percent of celery growers on mineral soils apply nitrofen as a preemergence spray usually in sequence with other herbicides. The cost of these treatments is about $40 per acre (Table 2).

If nitrofen were not available for use on celery, growers would be expected to substitute an alternative weed control program including prometryne, chloroxuron, mineral spirits, or trifluralin, at a higher treatment cost per acre. When alternative herbicides are used in the place of nitrofen, growers would have to use additional mechanical cultivations and hand hoeings for adequate weed control. Alternative weed control programs differ from region to region; therefore, the alternative treatment costs per acre vary by region depending on the alternative herbicide used, its rate of application, the number of additional cultivations and hand weedings required for adequate weed control. The programs for the regions are discussed in the ensuing subsections.

<u>California</u>

The alternative weed control programs for the affected acreage if nitrofen were withdrawn from the market are as follows: 38 percent of the celery acreage is to be treated with prometryne, 47.5 percent with prometryne plus chloroxuron, 9.5 percent with prometryne plus chloroxuron and mineral spirits, and the remaining 5 percent with chloroxuron. The use

Type of soils	Weed control program	Application rate (lbs. a.i./acre)	Material cost/lb. a.i.	Material cost/acre	Application cost/acre	Additional cultivation cost/acre b/	Additional hand weeding cost/acre c/	Weed control cost/acre	Change in weed control cost/acre e/	Treated acres	Total change in weed control cost
			Dollars							$1,000	$1,000
Current											
Mineral	Nitrofen	4.	7.94	31.76	8.00	-	-	39.76	-	14,668	-
Muck	Nitrofen	5.	7.94	39.70	8.00	-	-	47.70	-	13,967	-
Alternative											
Mineral											
Calif. (1)	Prometryne	2.	6.44	12.88	8.00	16.00	375.00	411.88	372.12	5,348	1,990.1
(2)	Prometryne +	2.+	6.44	26.28	16.00	16.00	375.00	433.28	393.52	6,685	2,630.7
	Chloroxuron	2.	6.70								
(3)	Prometryne +	2.+	6.44	101.28	24.00	16.00	375.00	516.28	476.52	1,337	637.1
	Chloroxuron +	2.+	6.70								
	Mineral Spirits	60 gal.	1.25								
(4)	Chloroxuron	2.	6.70	13.40	8.00	16.00	375.00	412.40	372.64	704	262.3
Other States	Trifluralin	.5	8.05	4.03	18.00	32.00	-	54.03	14.27	594	9.8
Muck											
Florida (1)	Prometryne	2.	6.44	12.88	8.0	8.0	75.00	103.88	56.18	2,273	127.7
(2)	Linuron	1.	10.80	10.80	8.0	8.0	75.00	101.80	54.10	9,094	492.0
Michigan (1)	Prometryne	2.	6.44	12.88	8.0	16.00	120.00	156.88	109.18	2,340	255.5
(2)	Linuron	1.	10.80	10.80	8.0	16.00	120.00	154.80	107.10	260	27.8
Total		-	-	-	-	-	-	-	-	-	6,433.0

a/ Application cost is $8.00 for spraying a chemical per acre, $18.00 for incorporating a chemical per acre.
b/ $8.00 per time.
c/ Cost for hand hoeing is based on $7.50/hour.
d/ Did not include the cultivation and hand weeding costs under the current (nitrofen) treatment program.
e/ Based on the current (nitrofen) treatment program.

of these alternative herbicides all will require 2 additional mechanical cultivations and 2 additional hand weedings. These alternative programs would increase weed control costs by about $372 to $477 per acre (Table 2). Based on the average of 1977 and 1980 budget estimates for celery growers in Santa Barbara County of California (about $4,543 per acre), the increase in weed control costs would represent a 8.2 to 10.5 percent increase in overall production costs. By using alternative herbicides and assuming growers do not change the number of planted acres, the total weed control costs will increase by a total amount of $4.8 million for impacted California celery growers (Table 2).

New York, Ohio and Washington

For New York, Ohio and Washington, the alternative weed control program will use trifluralin with 4 additional cultivations. This alternative program would increase weed control costs by $14 per acre. Based on the average of 1977 and 1980 budget estimates for Santa Barbara County of California, this increase in weed control costs would represent a .3 percent increase in total production costs for these states. The increase in total production costs for these states is $9,800.

Muck Soils (Florida, Michigan)

Approximately 14,000 acres of celery are grown on muck soils in Florida and Michigan; all acres are treated with nitrofen (Table 3). On these muck soils, nitrofen is applied as a postemergence spray (usually 3 weeks after transplant) in sequence with other herbicides. The cost of treatments is about $48 per acre (Table 2).

Growers in these 2 states would substitute prometryne and linuron programs to control weeds if nitrofen were suspended.

Florida

If nitrofen is not available for use on celery, 80 percent of the celery acreage would be treated with linuron and 20 percent with prometryne. The use of these alternative herbicides in Florida requires additional cultivation and hand weeding. The alternative programs would increase the weed control costs by about \$54 to \$56 per acre. Based on budget estimates for celery growers in Santa Barbara County of California, this increase is about 1.2 percent increase in the total costs of celery production. The total increase in the costs of production in Florida is \$619,700.

Michigan

In Michigan 90 percent of the celery acreage will be treated with prometryne and 10 percent with linuron if nitrofen is not available. When alternative herbicides are used, the growers will need 2 additional cultivations and hand weedings for effective weed control. The alternative programs will cause the weed control costs to increase by \$107 to \$109 per acre which is about 2.4 percent of the total costs of production (based on California budget estimates). The cost of producing celery in Michigan will increase by a total amount of about \$283,300 if the production acreage remains the same.

The use of alternative weed control programs on the 28,728 acres of celery currently treated with nitrofen in all six states would increase production costs by about 6.43 million dollars per year.

Impact on Output and Revenue

About 28,728 acres of celery production will be affected if nitrofen is not available. This acreage produced about 79 percent of the 1977-1979 total celery production in the United States. The restriction of the use of nitrofen on celery should have some impact on celery production and its growers' revenue. The impacts on output and farm revenue will vary from region to region depending on each region's alternative weed control program, the proportion of affected acreage relative to the total celery acreage, and the importance of celery production in the region.

California is the most important celery producing state supplying 58 percent of the celery produced in the U.S. (Table 3). About 67 percent of the California celery acreage (14,074 acres) is treated with nitrofen. If treated with alternative herbicides, 95 percent of the California celery acreage would suffer a decrease in quality of about $1,125 per acre which is about 26 percent of the value of production per acre. The remaining 5 percent of California's celery acreage, which would be treated with chloroxuron as an alternative, would suffer a 23 percent yield loss. Altogether the total annual loss amounts to about 15.9 million dollars for California celery production if the price of celery remains unchanged (Table 3).

By using alternative weed control programs, celery grown in Washington, New York, and Ohio will suffer a 15 percent yield loss totalling about 44,242 cwt. at an estimated value of $469,320 per year. Florida is not expected to suffer any output loss by using other alternative controls. Michigan will have a 10 percent yield loss on the affected acreage for a total loss of 105,300 cwt. with a market value of 1.1 million dollars.

Table 3. Average (1977-1979) U.S. Acreage, Yield, Production and Value of Production for Celery a/

State	Planted acres	Treated acres	Yield per acre	Total production	Production from treated acreage	Average price	Value of total production
			cwt.	1,000 cwt.	1,000 cwt.	$/cwt.	$1,000
Mineral Soil							
California	20,061.	14,074.	539.	11,361.	7,592.	9.11	103,532.
Washington	280.	135.	468.	131.	63.4	9.86	1,292.
New York	650.	325.	414.	269.	134.5	11.24	3,024.
Ohio	327.	224.	434.	142.	97.3	10.22	1,451.
Subtotal	22,131.	14,758	534.	11,903.	7,887.2	9.18	109,299.
Muck Soil							
Florida	11,367.	11,367.	353.	4,007	4,007.	11.74	47,035.
Michigan	2,600	2,600	405.	1,054.	1,054.	10.45	11,011.
Subtotal	13,967.	13,967.	362.	5,061.	5,061.	11.47	58,046.
Total	36,285.	28,725.	468.	16,964.	12,948.	9.86	167,345.

a/ USDA/USEPA/States, 1980.
USDA, Vegetables 1979 Annual Summary, 1980.

The use of alternative herbicides would cause an average quality loss of about $1,125 per acre for 13,370 acres of California's affected celery acreage (14,074 acres), and reduce industry output by about 1.5 percent for the rest of the U.S. Assuming the decrease in quality of celery can be expressed in terms of quantity 1/, the total reduction in industry output is estimated to be 11.2 percent. The loss in the value of production (including both quantity and quality decreases) from using alternative herbicides is estimated to be $17.5 million annually.

The impact of this short run reduction in output on market prices and grower revenue may be estimated through an analysis of the price elasticity of demand which measures the percentage change in quantity demanded associated with a percentage change in price of the same product. Although current estimates of price elasticity are unavailable, past market studies of celery and other vegetables suggest that demand at the farm level is relatively inelastic (Brandow, 1961; Waugh, 1964; Shaefer, 1965). The demand elasticity for celery at the farm level ranges from -.3 to -.9, or an average of -.6 which is fairly inelastic. At the farm level, buyers tend to respond to reductions in supply by bidding up the market price at a rate that is higher than the rate of output reduction. This relative inelasticity of demand may be explained by the fact that celery has few good substitutes and its purchase constitutes a small part of the consumer's food budget.

If this range of estimates reflects current demand, the estimated supply reduction (resulting from the use of alternative herbicide programs) would cause grower prices to rise by about $1.10 to $3.67 per cwt. (Table 6). As an average, the reduced production of about 1.9

1/ See footnote b in Table 4.

Table 4. Annual Yield/Quality Reductions Resulting from a Nitrofen Suspension on U.S. Celery a/

State	Yield Reduction on Treated Acreage				
	Percent	Cwt/acre	Value Cost/acre	Total reduction	Total lost value
			$/acre	1,000 cwt.	$1,000
Mineral Soils					
California b/	23.	124.0	1,130.	1,745.2	15,903.6
Washington	15.	70.2	692.	9.5	93.4
New York	15.	62.1	698.	20.2	226.9
Ohio	15.	65.1	665.	14.6	149.0
Subtotal		121.3	1,109.	1,789.5	16,372.9
Muck Soil					
Florida	0.	0.	0.	0.	0.
Michigan	10.	40.5	423.	105.3	1,099.8
Subtotal		40.5	423.	105.3	1,099.8
Total		109.1	1,006.	1,894.8	17,472.7

a/ USDA/USEPA/States, 1980.
USDA, Vegetables, 1979 Annual Summary, 1980.

b/ About 5 percent of California's affected celery acreage, which would use chloroxuron as an alternative if nitrofen is not available, would suffer a 25 percent yield loss. For the remaining 95 percent of California's impacted celery acreage, the loss in quality due to the use of alternative weed control programs is estimated to be $1,125/acre (Footnote 6, Table 1), which is about 22.9 percent of the value of production per acre (539 cwt/acre x $9.11/cwt. = $4,910/acre). This assumes that the quality reduction is equivalent to a quantity loss of 22.9 percent. The reduction in the production for California's impacted celery acreage is calculated as:

(539 cwt/acre x .229 x 14,074 acres x .95)
+ (539 cwt/acre x .25 x 14,074 x .05)
= 1,745.79 cwt.

Reduction in the production per acre is 1,745.79 cwt/14,074 acre
= 124 cwt/acre or 23 percent.

million cwt. will cause price to increase by $1.84 per cwt. for the impacted growers. This price increase would not be sufficiently high to offset revenue losses due to reduced production. The affected growers would incur a loss of revenue estimated at about $5.7 million per year (Table 6). If price elasticity falls within the range of -.30 to -.90, the estimated yield reduction would cause grower prices to rise by about $3.67 to $1.10 per cwt. (Table 6). The revenue impact on the affected growers would range from a revenue increase of about $7.1 million (assuming a price elasticity of -.30) to a revenue loss of about $10.9 million (assuming a price elasticity of -.90) (Table 6).

In the short run, assuming the price elasticity of celery is -.6, the net economic loss to affected growers would be about$12.2 million (Table 7). For the unaffected growers, the $1.84 per cwt. increase in price would increase short term annual revenue by approximately $14.8 million.

The short term increases in celery prices would be an incentive for growers in unaffected areas to either begin or expand production. In the long run, this increased production would reduce farm prices from the initial impact level. Without the development of biological and cost effective weed controls, some of the impacted growers would be expected to reallocate their land to other crops less affected by a nitrofen suspension.

Market and Consumer Impacts

The use of alternative herbicides in place of nitrofen would reduce the short run industry supply of celery by about 1.9 million cwt. (Table 5), or by about 11.2 percent of the 1977-79 average industry output of 17.0 million cwt. This short run reduction of output would be expected to

have an impact on prices at the retail level. By assuming price elasticity of celery is -.6 and all of the estimated increase in grower price ($1.84 per cwt.) is passed on to consumers, the consumer surplus is decreased by about $29.5 million.

In the short run, the reduced supply and higher retail prices would cause some consumers to substitute other vegetables for their current purchases of celery. In the long run, higher grower prices would stimulate new and expanded production which would increase the output of celery and reduce the initial impact on retail prices and supply. However, the new market price for celery would probably be higher than they are now, if nitrofen is suspended.

Macroeconomic Impacts

If alternative weed control programs are used by the affected growers, the production costs will be increased by $6.4 million. The change in growers' revenue for celery growers will be increased by about $9.0 million. This will result in an increase of $2.6 million in net farm income for growers. However, the consumer surplus will decrease by an amount of $29.5 million due to the higher price. This results in an increase of social costs by about $26.9 million per year if nitrofen is suspended.

Social and Community Impacts

Data limitations make it difficult to assess the social and community impacts of cancelling nitrofen use on celery. If the production of this crop is an important source of income and employment to the local economy, the cancellation of nitrofen use would certainly impact the local economy.

Table 5. Estimated Change in Celery Price at the Farm Level Resulting from a Reduction in Celery Production

Celery production 1/ 1,000 cwt.	Reduced celery production 2/ 1,000 cwt.	Current industry price 3/ $/cwt.	Elasticity 4/	Expected price increase 5/ $/cwt.
16,964	1,894.8	9.86	-.30	3.67
			-.60	1.84
			-.90	1.10

1/ 1977-79 U.S. average (Table 3).
2/ Output reduction resulting from use of alternative weed control programs (Table 4).
3/ 1977-79 U.S. average (Table 3).
4/ Price elasticity is assumed to range between -.30 and -.90; in average, the price elasticity of celery at the farm level is -.6.

5/ Calculated from the equation: Elasticity of Demand $= \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$

Table 6. Revenue Impact of a Nitrofen Suspension on Affected Celery Growers

	Treated acreage a/	Output 1,000 cwt.	Price elasticity	Price per cwt/ c/	Revenue ($1,000)	Revenue change ($1,00
With Nitrofen						
	17,361	8,941. a/	—	9.86	88,158.3	—
Without Nirtofen						
	17,361	7,046.2 b/	-.30	13.53	95,335.6	+7,176.
			-.60	11.70	82,440.5	-5,717.
			-.90	10.96	77,226.4	-10,931.

a/ Does not include Florida, because it would not suffer any yield or quality loss by usi alternative weed control programs. The treated acreage for the affected growers would 17,361 acres = 28,635 acres (total U.S. treated acreage with nitrofen) - 11,367 acres (Florida treated acreage). The output for affected growers excluding Florida is 8,941 cwt. (Table 3) with nitrofen.

b/ Assuming a total output reduction of 1,894,800 cwt.

c/ Elasticity of demand at the farm level assumed to range between -.3 to -.9 with an ave of -.6.

Table 7. Short Term Economic Impact of a Nitrofen Suspension of U.S. Celery Industry (1980) a/

	Impacted Growers ($1,000)	Non-Impacted Growers ($1,000)	Industry ($1,000)
Change in Production Costs b/	+6,343.0	0	+6,433.0
Change in Grower Revenue c/	-5,717.8	+14,762.3	+9,044.5
Change in Net Farm Income d/	-12,150.8	+14,762.	+2,611.2
Change in Consumer Surplus e/	—	—	-29,470.5
Total Social Cost f/	—	—	-26,859.3

a/ Based on the average celery price elasticity of -.6.
b/ See Table 2.
c/ See Table 6 for affected growers. The change in revenue for the non-impacted growers is the increase in price ($1.84/cwt.) times the total production of 8,023 thousand cwt., which includes 4,007 thousand cwt. from Florida.
See Table 6 for affected growers. The change in grower revenue for the non-impacted growers is the increase price ($1.84/cwt.) times production from non-impacted growers. e/ Change farm income = change in grower revenue - change in production costs.
f/ Change in consumer surplus is computed by:

$$1/2 \, (P_1 - P_2) \times (Q_1 - Q_2) + (P_1 - P_2) \times Q_2$$

where: P_2 and P_1 are the price of celery without and with nitrofen.
Q_2 and Q_1 are the celery production without and with nitrofen.

f/ Social costs of a nitrofen suspension on celery is equal to the change in consumer surplus plus change in net farm income.

Limitations of Analysis

1. It has been assumed that any additional labor required for the alternative weed control programs is readily available at prevailing market prices.
2. The projection of the changes in the production costs and farm income is based on the average 1977-1979 prices of herbicides and celery.
3. It is uncertain if the nonavailability of nitrofen will force celery growers into the production of other crops in the longer run.
4. Lack of farm budget data for states other than California.
5. Seasonality factors were not considered in the analysis.

DRAFT

DEC 11 '80

ECONOMIC IMPACT ANALYSIS ~~ON GARLIC~~ OF NITROFEN USE ON GARLIC

B. Ted Kuntz[1/]

The estimated economic impact of canceling ~~Tok uses~~ nitrofen use on garlic was based on the following procedures and assumptions:

1. ~~Tok~~ Nitrofen is applied once during the growing season. ~~Tok is applied~~ as a post-emergence (2-leaf stage) broadcast treatment. Principle problem weeds controlled are cheeseweed, stinging nettle, nightshade, pigweed, purslane, and pineapple weed.

2. California 1977-79 average planted acreage, yield per planted acre, and value per hundredweight were used as a base for the analysis.

3. The base acreage treated with ~~Tok~~ nitrofen was estimated by agricultural scientists working in the garlic-producing areas (table 1). Only the acres currently treated are included in the analysis.

4. The alternative weed-control program was specified by agricultural scientists (table 1). This alternative program was assumed to be the best program available if ~~Tok~~ nitrofen were canceled. Market availability and efficacy of the alternatives were considered in specifying the alternative program.

5. It was assumed that no new alternatives will become available in the near term, that the prices for alternative herbicides

---

B. Ted Kuntz is an Agricultural Economist for the Economics and Statistics Service, Natural Resource Economics Division, U.S. Department of Agriculture, Corvallis, Oregon.

Table 1.--Current use and costs of nitrofen ~~Tok~~ and potential alternatives for weed management in garlic, California

Alternative treatment	Acres: Planted[a]	Acres: Treated[b]	Number of applications[b]	Pound a.i.: Per acre[b]	Pound a.i.: Total	Material cost per pound a.i. or labor cost per acre	Per acre treatment cost: Materials	Per acre treatment cost: Application[b]	Per acre treatment cost: Total	Total cost	Change in costs using best alternative: Per acre	Change in costs using best alternative: Total
						Dollars						
Weed-control programs with Tok	12,533											
DCPA ~~Dacthal~~ (pre)......		3,947	1	10.0	39,470	5.27[c]	52.70	18.00	70.70	279,053		
Dinoseb (pre)......		2,632	1	1.0	2,632	5.70[c]	5.70	18.00	23.70	62,378		
nitrofen ~~Tok~~ (post).........		4,386	1	4.0	17,544	7.94[c]	31.76	9.00	40.76	178,773		
DCPA ~~Dacthal~~ (post).....		3,070	1	10.0	30,700	5.27[c]	52.70	9.00	61.70	189,419		
Chloropropham......		439	1	4.0	1,756	4.09[c]	16.36	9.00	25.36	11,133		
Chloruxuron........		439	1	2.0	878	6.70[c]	13.40	9.00	22.40	9,834		
Hand weeding.......		4,386	1	--	--	50.00[d]	--	50.00	50.00	219,300		
									294.62	949,890		
Alternative weed-control program	12,533											
DCPA ~~Dacthal~~ (pre)......		3,947	1	10.0	39,470	5.27[c]	52.70	18.00	70.70	279,053		
Dinoseb (pre)......		2,632	1	1.0	2,632	5.70[c]	5.70	18.00	23.70	62,378		
bromoxynil ~~Brominal~~ (post)....		4,386	1	0.5	2,193	10.20[c]	5.10	9.00	14.10	61,843		
bromoxynil ~~Brominal~~ (post)....		4,386	1	0.5	2,193	10.20[c]	5.10	9.00	14.10	61,843		
DCPA ~~Dacthal~~ (post).....		3,070	1	10.0	30,700	5.27[c]	52.70	9.00	61.70	189,419		
Chloropropham......		439	1	4.0	1,756	4.09[c]	16.36	9.00	25.36	11,133		
Chloruxuron........		439	1	2.0	878	6.70[c]	13.40	9.00	22.40	9,834		
Hand weeding.......		4,386	1	--	--	75.00[d]	--	75.00	75.00	328,950		
Hand weeding.......		4,386	1	--	--	100.00[d]	--	100.00	100.00	438,600		
									407.06	1,443,053	112.44	493,163

a/ U.S. Department of Agriculture, ESCS, CRB, Vegetables, 1979 Annual Summary, Acreage, Yield, Production, and Value, June 6, 1980.

b/ Harry S. Agamalian and Harold M. Kempen.

c/ AGCHEMPRICE, 7-15-80.

d/ Harry S. Agamalian.

will not change, and the alternative will be available in sufficient quantities. It was also assumed that sufficient labor will be available for hand weeding at prevailing market prices.

6. An estimated 10 percent production loss is assumed with the alternative treatment program. This production loss includes: (1) loss of bulbs at harvest due to the bulbs binding up in weed roots and failing to be separated by the mechanical harvester, (2) smaller cloves and bulbs from weed competition, and (3) increased weediness in subsequent crops because of increased carryover weed seed on ~~rhisomes.~~ rhizomes. Yield losses associated with the ~~less effective~~ alternative weed-control program were estimated by agricultural scientists in the garlic-producing areas. These estimates were based on their experience and judgment about annual variations in production associated with different herbicides and hand weeding under general field conditions, and data from experimental research plots. However, research plot data may vary from actual field experience because they are obtained under specialized conditions.

7. Partial budgeting techniques were used to estimate the economic impact of a ~~Tok~~ nitrofen cancellation.

8. The treated acres are all in the garlic-growing areas on the coast of California.

Results

The 1977-79 average planted acres of garlic in California was 12,533. Average value for garlic in the same period was $15.17 per

hundredweight. Total production and value were 1,517,000/ hundredweight and $23,011,000, respectively.

An estimated 4,386 acres of garlic are treated annually with ~~Tok.~~ nitrofen. About 4 pounds a.i. per acre, or a total of 17,544 pounds a.i. of nitrofen ~~of Tok~~ are applied each year (table 1). At the current price of $7.94 per pound (a.i.), the material cost of ~~Tok~~ nitrofen is $31.76 per acre. Application cost is $9 per acre. Total expenditures for ~~Tok~~ nitrofen use on garlic is $189,419. Total cost of the herbicide and handweeding portion of the weed-control program including ~~Tok~~ nitrofen is $949,890.

The alternative weed-control program includes two applications of the recently registered herbicide, ~~Brominal, one~~ bromoxynil, with two more expensive handweeding ~~and one additional hand weeding~~. Total cost of the alternative program is estimated to be $1,443,053, an increase in cost of $493,163, or about $112 per acre.

Use of the alternative ~~less effective~~ weed-control program is expected to result in a 10 percent yield decrease on the 4,386 acres currently treated. Average yields for 1977-79 were 121 hundredweight. Therefore, at a value of $15.17 per hundredweight of garlic, production losses of ~~$805,072~~ $805,081 are estimated for the first year without ~~Tok.~~ nitrofen. Additional losses would be expected as the weed population increases in subsequent years.

Total losses, including increased treatment costs and reduced production, are estimated to be $1.3 million the first year without ~~Tok.~~ nitrofen

The data base is inadequate to determine if the 3.5 percent decrease in garlic production in California would result in measurable price changes at the market or consumer level.

Summary

Total losses, including increased treatment costs and reduced production are estimated to be $1.3 million the first year without ~~Tok.~~ nitrofen. The 3.5 percent decrease in garlic production in California is valued at ~~$805,072~~ $805,051 and increased weed-control costs are estimated to be $493,163 or about $112 per acre.

ECONOMIC IMPACT ANALYSIS of NITROFEN USE

ON HORSERADISH

B. Ted Kuntz[1/]

The estimated economic impact of canceling ~~Tok uses~~ nitrofen use on horseradish was based on the following procedures and assumptions:

1. ~~Tok~~ Nitrofen is applied once during the growing season. In California, it is estimated that 50 percent of the ~~Tok~~ nitrofen is applied as a pre-emergence incorporated treatment and 50 percent as post-emergence broadcast treatment. In the ~~m~~Midwest, ~~Tok~~ nitrofen is applied as a post-emergence broadcast treatment. (The ~~m~~Midwest includes Illinois, Indiana, Wisconsin, and Missouri. Minor acreage~~s~~ treatments occur in Pennsylvania, New Jersey, and Maryland.) Principle problem weeds controlled are ____

____.

2. U.S. 1977-79 average planted acreage, yield per planted acre, and value per hundredweight were used as a base for the analysis.

3. The base acreage treated with ~~Tok~~ nitrofen was estimated by agricultural scientists working in the horseradish-producing areas (table 1). Only the acres currently treated are included in the analysis.

1/ B. Ted Kuntz is an Agricultural Economist for the Economics and Statistics Service, Natural Resource Economics Division, U.S. Department of Agriculture, Corvallis, Oregon.

Table 1.--Current use and costs of ~~Tok~~ nitrogen and potential alternatives for weed management in horseradish, California and Midwest

Nitrogen ~~Area~~ and alternative treatments by area	Acres treated[a]	Number of applications[a]	Pound a.i. Per acre[a]	Pound a.i. Total	Material cost per pound a.i. or labor cost per acre	Per acre treatment cost Materials	Per acre treatment cost Application[a]	Per acre treatment cost Total	Total cost	Change in costs using best alternative Per acre	Change in costs using best alternative Total
					Dollars						
California:	500										
Nitrogen ~~Tok~~ (pre)	250	1	5	1,250	6.93[b]	34.65	18.00	52.65	13,163		
Nitrogen ~~Tok~~ (post)	250	1	5	1,250	6.93[b]	34.65	9.00	43.65	10,913		
								48.15[c]	24,076		
Alternative:											
DCPA ~~Dacthal~~	500	1	8-10	4,000 to 5,000	5.27[b]	42.16 to 52.70	9.00	51.16 to 61.70	25,580 to 30,850		
Incr. cultivation	500	1-2			10.00[a]		10.00	10.00 to 20.00	5,000 to 10,000		
Incr. hand labor	500	1			50.00[a]		50.00	50.00	25,000		
								111.16 to 131.70	55,580 to 65,850	63.01 to 83.55	~~31,504~~ 31,505 to ~~41,774~~ 41,775
Midwest:											
Nitrogen ~~Tok~~ (post)	1,250	1	4	5,000	6.93[b]	27.72	9.00	36.72	45,900		
Alternative:											
DCPA ~~Dacthal~~	1,250	1	8-10	10,000 to 12,000	5.27[b]	42.16 to 52.70	9.00	51.16 to 61.70	63,950 to 77,125		
Incr. cultivation		3X			10.00[a]		10.00	30.00	37,500		
Incr. hand labor		3X			50.00[a]		50.00	150.00	187,500		
								231.16 to 241.70	288,950 to 302,125	194.44 to 204.98	243,050 to 256,225

a/ Alan R. Putman.

b/ AGCHEMPRICE, 7-15-80.

c/ Weighted average.

4. The alternative weed-control program was specified by agricultural scientists (table 1). This alternative program was assumed to be the best program available if ~~Tok~~ nitrogen were canceled. Market availability and efficacy of the alternatives were considered in specifying the alternative program.

5. It was assumed that no new alternatives will become available in the near term, that the price~~s~~ for the alternative herbicide~~s~~ will not change, and the alternative will be available in sufficient quantities. It was also assumed that sufficient labor will be available for hand weeding at prevailing market prices.

6. It is assumed that a production loss will not occur with the alternative treatment program.

7. Partial budgeting techniques were used to estimate the economic impact of a ~~Tok~~ nitrogen cancellation.

Results

The 1977-79 average planted acres of horseradish in the U.S. was 2,200. Average value for horseradish in the same period was $_____ per hundredweight. Total production and value were ___________ and _______________, respectively.

An estimated 1,750 acres of horseradish are treated annually with ~~Tok~~ nitrogen in California and the midwest.

California

An estimated 500 acres in California are treated with 5 pounds

of ~~Tok~~ nitrogen per acre or a total of 2,500 pounds a.i. each year (table 1). At the current price of $6.93 per pound (a.i.), the material cost of ~~Tok~~ nitrogen is $34.65 per acre. Per acre application cost is $18 for pre-emergence incorporated treatment and $9 for post-emergence broadcast treatment. Total expenditures for ~~Tok~~ nitrogen use on horseradish in California are $24,076.

The alternative weed-control program in California includes one application of the herbicide ~~Dacthal~~ DCPA, one or two additional cultivations, and additional hand weeding. Total cost of the alternative program is estimated to ~~be~~ range from $55,580 to $65,850, an increase in cost of ~~$31,504~~ $31,505 to ~~$41,774~~ $41,775 or about $63 to $84 per acre.

Midwest

An estimated 1,250 acres of horseradish in the ~~midwest~~ Midwest are treated with 4 pounds a.i. of nitrogen ~~of Tok~~ per acre, or a total of 5,000 pounds a.i. each year (table 1). The per acre cost of a ~~Tok~~ nitrogen treatment is $27.72 for the herbicide and $9.00 for application, or a total of $36.72. Total expenditures for ~~Tok~~ nitrogen use on horseradish in the ~~midwest~~ Midwest are $45,900.

The alternative weed-control program in the ~~midwest~~ Midwest includes one application of the herbicide ~~Dacthal~~ DCPA, three additional cultivations, and three additional hand weedings. Total cost of the alternative program is estimated to be $288,950 to $302,125, an increase in cost of $243,050 to $256,225 or about $194 to $205 per acre.

Total losses from the increased treatment costs for weed control in horseradish are estimated to be ~~$274,554~~ $274,555 to ~~$297,999~~ $298,000 the first year without ~~Tok.~~ nitrogen. Additional losses may occur as the weed population increases in subsequent years.

Summary

An estimated 1,750 acres of horseradish are treated with 7,500 pounds a.i. of nitrofen ~~of Tok~~ for weed control annually. Use of the alternative weed control program will increase treatment costs by ~~$274,544~~ $274,555 to ~~$297,999~~ $298,000 the first year without ~~Tok~~ nitrofen.

Preliminary Benefit Analysis of Nitrofen Use on Kale, Collards and Mustard Greens for Processing

Current Use Analysis

EPA Registrations of Nitrofen and Alternatives

Nitrofen formulated as either a 25 EC or 50 WP is registered as a weed control for various annual grasses and broadleaf weeds on kale, collards and mustard greens (leafy vegetables). Hawaii is the only state with a registration for this use (Intrastate Reg. Nos. 37843-8529 and 37843-8530, EPA 1980). The primary target weeds include malva, burning nettle, purslane, ground cherry, oxalis, hairy nightshade, pigweed, black nightshade, nettleleaf goosefoot, annual morning glory and silversheath knotweed (USDA/EPA/States, 1980). A single pre-or post emergence spray application of 3-6 pounds a.i. mixed with 50 to 100 gallons of water is the labeled rate per acre (EPA, 1980). For leafy vegetables to be processed, nitrofen is typically applied as a pre-emergence treatment at a rate of 4 pounds a.i. per acre (USDA/EPA/States, 1980). The nitrofen treatment is supplemented with a trifluralin or DCPA application and requires an 8-10 hour hand weeding. The high density population planting configuration of collards and mustard greens does not lend itself to close cultivation, the kale crop requires cultivation 2-3 times (USDA/EPA/States, 1980).

Trifluralin, DCPA and CDEC are registered weed controls on leafy vegetables but are considered less reliable than nitrofen by the growers (USDA/EPA/States, 1980). The spectrum of weeds controlled by the alternatives is not as broad as that controlled by nitrofen.

Use of Nitrofen and Alternatives

The total number of acres treated with nitrofen in Hawaii is not currently available; hence, the assessments will be limited to a typical per acre basis.

Nitrofen is always used in combination with other herbicides when applied to leafy vegetables. A preplant incorporated treatment of trifluralin (0.5 lbs. a.i./acre) plus a preemergence spray of nitrofen (4.0 lbs. a.i./acre) is probably the preferred treatment. Some acreage may receive a preemergence spray application of DCPA (8.0-10.0 lbs. a.i./acre) plus a preemergence spray of nitrofen (4.0 lbs. a.i./acre). The combination of preplant incorporating CDEC (4.0 lbs. a.i./acre) plus nitrofen (4.0 lbs. a.i./acre) is rarely used due to the erratic performance of CDEC (USDA/EPA/States, 1980).

Table 1. Use of Nitrofen and the Alternatives on Leafy Vegetables (Kale, Collards and Mustard Greens) for Processing in Hawaii[a/]

Weed Control Program	Timing of Application	Application Rate/Acre (lbs. AI)	Number of Applications	Number of Cultivations [b/]	Number of Hand Weedings [c/]	Pre-irrigation [d/]	Percent Yield Reduction	Change in Crop Quality
Nitrofen Programs								
1. Trifluralin	preplant incorporated	0.5	1	2-3	1			
+ Nitrofen	preemergence	4.0	1					
2. DCPA	preemergence	8.0-10.0	1	2-3	1			
+ Nitrofen	preemergence	4.0	1					
Alternative Programs								
1. Trifluralin	preplant incorporated	0.5	1	4-5	2	1 [d/]	15	[e/]
2. DCPA	preemergence	8.0-10.0	1	4-5	2	1	15	

a/ Based on average data for 1977-79 estimated by USDA/EPA/States Assessment Team.

b/ Applies to kale only; the planting configuration of collards and mustard greens does not lend itself to close cultivation.

c/ 8-10 man hours per weeding.

d/ Crops are currently grown under sprinkler irrigation. Without nitrofen a pre-irrigation is required to enhance weed germination.

e/ Grower is charged a dockage fee of 2.5¢/pound when weed pieces are mixed in with the harvested crop.

Source: USDA/EPA/States, 1980.

Without nitrofen leafy vegetable producers would continue to use trifluralin or DCPA. Each alternative will require 1 additional hand weeding (8-10 hours) and a pre-irrigation for all crops and 2 additional cultivations for kale. Annual yields would be expected to decline 15 percent for each crop. On a per acre basis the following yield losses are expected: decline of 900 pounds for kale, 1,200 pounds for collards and 1,800 pounds of mustard greens (Table 1).

Economic Impact Analysis

Production Cost Changes

The weed control costs for the kale crop differ from the costs for the collard and mustard green crops since kale has an additional cost for cultivation. The per acre cost of the nitrofen + trifluralin program ranges from $127.74 to $168.74 for kale and $107.74 to $132.74 for collards and mustard greens (Table 2). The cost of the alternative (trifluralin only) ranges from $173.02 to $243.02 per acre for kale, an increase of $45.28 to $74.28. For collards and mustard greens the per acre cost of the alternative ranges from $133.02 to $183.02, an increase of $25.28 to $50.28.

Table 2. Comparative Weed Control Costs for Nitrofen and Alternatives Used on Kale, Collards and Mustard Greens in Hawaii

Weed Control Program	Herbicide Cost a/ ($/acre)	Application Cost b/ ($/acre)	Cultivation Cost c/ ($/acre)	Hand Weeding Cost d/ ($/acre)	Additional Irrigation Cost ($/acre)	Weed Control Cost/Acre for Kale ($/acre)	Weed Control Cost/Acre for Collard and Mustard Greens
Nitrofen Program A							
Trifluralin	4.02	18.00					
+							
Nitrofen	27.72	8.00					
Total	31.74	26.00	20.00-36.00	50.00-75.00		127.74-168.74	107.74-132.74
Alternative							
Trifluralin	4.02	18.00	40.00-60.00	100.00-150.00	11.00	173.02-243.02	133.02-183.02
Net Change	-27.72	-8.00	20.00-24.00	50.00-75.00	11.00	45.28- 74.28	25.28- 50.28
Nitrofen Program B							
DCPA	42.16-52.70	8.00					
+							
Nitrofen	27.72	8.00					
Total	69.88-80.42	16.00	20.00-36.00	50.00-75.00		155.88-207.42	135.88-171.42
Alternative							
DCPA	42.16-52.70	8.00	40.00-60.00	100.00-150.00	11.00	201.16-281.70	161.16-221.70
Net Change	-27.72	-8.00	20.00-24.00	50.00-75.00	11.00	45.28-74.28	25.28- 50.28

a/ Price lb. AI: nitrofen EC, $6.93; trifluralin, $8.05; dacthal, $5.27.
b/ Rowe, G and B. Albertson, 1980.
c/ Applies only to kale. Cost is $10.00-$12.00/cultivation: 2-3 cultivations with nitrofen, 4-5 cultivations without nitrofen.
d/ Cost/hand weeding is $50.00-$75.00.

The per acre cost of the nitrofen + DCPA program ranges from \$155.88 to \$207.42 for kale, without nitrofen the cost ranges from \$201.16 to \$281.70 per acre (Table 2). Once again the net increase ranges from \$45.28 to \$74.28 per acre, the difference being the cost of nitrofen and the additional cultural practices required without nitrofen (e.g. cultivation, hand weeding, pre-irrigation). The cost of the nitrofen + DCPA program for collards and mustard greens ranges from \$135.88 to \$171.42 per acre, without nitrofen the cost ranges from \$161.16 to \$221.70; per acre net increase of \$25.28 to \$50.28.

Revenue Changes

Reduced output per acre by crop was estimated to be 900 pounds of kale, 1,200 pounds of collards and 1,800 pounds of mustard greens (Table 3). This is approximately 15 percent of average U.S. kale, collards and mustard green per acre production for processing. Without sufficient economic data (e.g. price elasticities of supply and demand) the magnitude of market price increases is unknown. Price increases or reduction in quantity would be accentuated in the short run. Short run price increases may lead to expanded production in the long run by non-impacted growers, new growers entering the market and increased imports into domestic market. Eventually the increased output may lower the price but not likely as low as the prevailing price with nitrofen.

Assuming the current market price does not change, the revenue loss per impacted acre would be about $45 for kale, $60 for collards and $90 for mustard greens (Table 3).

Additional revenue loss results from a dockage charge of $.025 per pound for weed pieces mixed in with the harvested crop. There was no data available to estimate the amount of crop that would be affected by this charge.

Net Farm Income Changes

Based on the assumption that hand labor costs and market prices for leafy vegetables (includes no dockage charge) will not change, the reduction in net farm income per impacted acre is estimated to range from $90.28 to $119.28 for kale, from $85.28 to $110.28 for collards and from $115.28 to $140.28 for mustard greens.

Potential Acreage Shifts

If net farm incomes are seriously impacted as a result of a regulatory action on nitrofen, growers will likely shift acreage to other crops in the long run. About 10-20 percent of impacted acreage may shift from leafy vegetables for processing to leafy vegetables for fresh market. The remainder of the impacted acreage would shift to producing other crops. The lost production may be replaced by imports or by increased production in non-impacted geographical areas.

Table 3. Average (1977-79) U.S. Acreage, Yield, Production and Value of Production for Kale, Collards and Mustard Greens a/

Crop	Yield Per Acre (lbs.)	Average Price/Pound (\$) b/	Percent Yield Reduction	Yield Reduction/ Acre (lbs.)	Value Lost/acre (\$) c/
Kale	6,000	0.05	15	900	45.00
Collards	8,000	0.05	15	1,200	60.00
Mustard Greens	12,000	0.05	15	1,800	40.00
Total					

a/ Leafy vegetables for processing only.

b/ This is 1977-79 average price of kale, collards and mustard greens, the fresh market price would be higher (Beste, E., University of Maryland).

c/ Assumes no change in price for the crop.

Source: USDA/EPA/States, 1980; Beste, E., University of Maryland.

Consumer Impacts

The higher production costs may be passed on to the consumer. It is not known what the consumer's reaction to price increases would be without sufficient demand and supply information. The farm price would not likely be a large percentage of the retail price (most of the value at this level being related to processing, transportation and other services), thus any consumer impacts would be small relative to farm impacts. Any consumer impacts will likely be limited to Hawaii. The magnitude of this impact cannot be determined due to the unavailability of usage data.

Macroeconomic Impacts

The macroeconomic impacts of cancelling nitrofen use on leafy vegetable for processing are expected to be negligible. If growers shift to other crops and lost production is replaced with imports, the macroeconomic impacts would still be negligible but more noticeable.

Social and Community Impacts

Data limitations make it difficult to assess the social and community impacts of cancelling nitrofen use on leafy vegetables for processing. Unavailability of crops may lead to the closing of processing plants in certain areas, unemployment, etc.

Limitations of Analysis

1. The number of acres treated in Hawaii is not known at the present time.

2. It has been assumed that any additional labor required for the alternative programs is readily available at prevailing market prices.

3. Farm income changes assume no change in the market price for any of the leafy vegetable crops. The 2.5¢ per pound dockage charge for weed pieces mixed in with the harvested crop was not included in the farm income impact analysis because it is not known what proportion of the harvested crop will be affected.

4. It is uncertain if the nonavailability of nitrofen will force leafy vegetable growers into the production of other crops in the longer term.

5. Limitations or nonavailability of marketing related information such as price elasticities of demand and supply.

6. There are no available data for leafy vegetable crops for fresh market.

REFERENCES

Beste, Ed. 1980. University of Maryland. Personal Communication November.

Rowe, Gordon and Barbara Albertson. 1980. Draft Inputs to TOK (nitrofen) Cultural Practices for Crops-Economic Impacts, University of California, Berkeley. Berkeley, California. July 14.

U.S. Department of Agriculture. 1980. U.S. Environmental Protection Agency and States Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen. Washington, D.C.

U.S. Environmental Protection Agency. 1980. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. July.

SUMMARY OF PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON ONIONS

A. USE: Nitrofen use on onions

B. MAJOR PESTS CONTROLLED:

annual bluegrass	lambsquarters	nettle	shepherdspurse
crabgrass	malva	pigweed	spergularia
goosefoot	nightshade	purslane	

C. ALTERNATIVES:

Major registered chemicals: DCPA, bensulide, dinoseb, sulfuric acid, chloroxuron, CDAA, and chloropropham.

Non-chemical controls: Mechanical cultivation and hand hoeing.

Comparative efficacy/performance: On muck soils, multiple applications of CDAA and chloropropham in the emulsifiable concentrate formulation would reduce yields by an estimated 10 to 15 percent. Where the granular formation is used, no yield losses would be expected. On mineral soils, the use of alternative herbicides would reduce yields by an estimated 15 to 20 percent.

Comparative costs:

Average Increase in Weed Control Costs per Acre:	Muck Soils	Mineral Soils
	79.46	33.50 - 34.60

On the muck soils of Michigan, New York, and Ohio, there would be an increase in production costs ranging from $68.60 to $82.64 per acre. On the mineral soils the change in production costs would range from a $9.86 per acre decrease (in Colorado) to a $537.09 per acre increase (in New York).

D. EXTENT OF USE: Amount of nitrofen applied to onions is estimated to be about 228,654 pounds a.i. per year. Nitrofen treated acreage is estimated at 58,726 acres, about 48% of total U.S. onion acreage. Estimates of annual usage by state are as follows:

State	Acres Treated	% of State Onion Acreage	State	Acres Treated	% of State Onion Acreage
Arizona	850	50	New York	14,467	100
California	4,113	13	Ohio	480	80
Colorado	3,983	50	Oregon	4,733	50
Idaho	2,550	50	Texas	15,217	50
Michigan	7,400	100	Utah	1,000	50
New Mexico	1,883	50	Washington	2,050	50

E. ECONOMIC IMPACTS:

User: The substitution of alternative weed control programs would increase production costs on the affected acreage by about $2.9 million per year. Assuming that market prices remain unchanged, the expected yield reductions on the affected acreage would reduce grower revenues by about $18.6 to $19.1 million per year. The total income loss to affected growers would be about $21.5 to $22.1 million per year.

In the long run, the reduction in revenue may cause some impacted growers to reallocate their land to other crops less affected by nitrofen suspension.

Market/Consumer: The use of alternative herbicides in place of nitrofen would reduce the short run supply of onions by about 2.5 to 2.6 million cwt., a reduction of about 7 percent in current output. This reduction in supply may cause retail prices to rise somewhat but data limitations prevent an estimate of the magnitude of these potential price increases. In the long run, higher prices at the grower level would stimulate new and expanded production which would increase the supply of onions and reduce the initial impact on retail prices.

Macroeconomic: No significant macroeconomic impact is expected.

F. SOCIAL COMMUNIT IMPACTS: Alternative weed control programs may require additional field labor. The increased demand for field labor may bid up wages and in some cases cause shortages of field labor.

The reallocation of land to other crops may lead to an increased demand for new farm equipment and other factors of production.

Short run reductions in onion output may cause some local processors to operate at a less than optimum level of output. In some cases, processors may need to search out more distant supply outlets or reinvest in new machinery capable of processing alternative crops.

G. LIMITATIOJNS OF ANALYSIS: There were significant data gaps with regards to the nature and extent of the weed control programs used on mineral soils. Estimates of comparative efficacy of nitrofen and alternative herbicides were not available for many of the impacted states. Due to the lack of data on price elasticities of demand and supply, prices at the farm level were assumed to remain constant.

H. PRINCIPAL ANALYSTS AND DATE:

Robert Esworthy and Allen Scneid
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

February, 1981

PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON ONIONS

Current Use Analysis

EPA Registration of Nitrofen and Alternatives

Nitrofen is a selective herbicide registered for use on onions to control the following weeds: anuual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, and spergularia (EPA, 1980). Nitrofen is applied at postemergence, usually in sequence with other herbicides such as DCPA, chloroxuron, sulfuric acid, CDAA, and chloropropham.

For all states except New York, the label directions for nitrofen use (in the wettable powder or emulsifiable concentrate formulation) call for a single postemergence application at 4 to 6 pounds active ingredient per acre, mixed with 40 to 60 gallons of water. On the mucklands of New York, multiple applications of nitrofen are allowed at the rate of .5 to 1.0 pound active ingredient per acre per application, with a limit of 6 pounds active ingredient per acre per season.

On mineral soils, the major alternative herbicides registered for use on onions are DCPA, bensulide (Texas and New Mexico), dinoseb (counties of Santa Clara, Monterey, and San Benito, California), sulfuric acid (Arizona and California), and chloroxuron (available only to growers who contract with Basic Vegetable Products, Inc.). On muck soils, the major alternative herbicides are CDAA and chloropropham.

Extent of Nitrofen Use

Of approximately 123,503 acres of onions currently grown in the United States (1977-79 annual average), an estimated 58,726 acres (48 percent) are treated with nitrofen (USDA/EPA/States, 1980). The total amount of nitrofen applied to onions each year is estimated to be about 228,654 pounds active ingredient (USDA/EPA/States, 1980).

About 66 percent of the treated acreage (38,879 acres) is located on the mineral soils of Arizona, California, Colorado, Idaho, New Mexico, New York, Oregon, Texas, Utah, and Washington. The remaining 34 percent of the treated acreage (19,847 acres) is located on the muck soils of New York, Michigan and Ohio.

Economic Impact Analysis

Production Cost Changes

Muck Soils (New York, Michigan, and Ohio)

Approximately 20,000 acres of onions (1977-79 annual average) are grown on the muck soils of New York, Michigan, and Ohio. Of this total acreage, an estimated 19,847 acres (99 percent) are treated with nitrofen (USDA/EPA/States, 1980).

The typical weed control program includes the use of the herbicides, CDAA and chloropropham, at early crop emergence. Nitrofen is applied at the early 3-leaf stage of onion growth and then repeated as needed with up to four applications per season. The cost per acre of these herbicide programs is estimated to be about $108.52 to $112.56 in New York and about $107.88 to $108.52 in Michigan and Ohio (Table 1). In addition to herbicide treatments, the weed control programs usually include about four mechanical cultivations and 1-2 stand up hoeing operations per season.

If nitrofen were unavailable for use on onions, growers would be expected to increase the number of CDAA and chloropropham applications from one to four per season. The cost of this alternative program would range between $176.48 to $195.20 per acre, depending on whether the emulsifiable concentrate or granular formulations were used (Table 2).

Table 1. Per Acre Cost of Nitrofen Weed Control Programs Used on Muck Soil Onions of New York, Michigan, and Ohio

State	Herbicide Program	Application Rate Per Acre (Lb. of A.I.)	Number of Applications Per Season	Herbicide Cost Per Lb. of A.I. ($)	Herbicide Cost Per Acre ($)	Application Cost Per Acre ($)	Herbicide + Application Cost Per Acre ($)	Number of Acres Treated
New York	CDAA (20G)+chloropropham (20G)	4 + 4	1	5.45 + 4.75	40.80	8.00	48.80	
	nitrofen (50 WP)	1	4	7.94	31.76	12.00	63.76	
							112.56	8,975
New York	CDAA (20G) + chloropropham (20 G)	4 + 4	1	5.45 + 4.75	40.80	8.00	48.80	
	nitrofen (4 EC)	1	4	6.93	27.72	12.00	59.72	
							108.52	2,992
Michigan, Ohio	CDAA (4 EC) + chloropropham (4 EC)	4 + 4	1	4.94 + 4.09	36.12	8.00	44.12	
	nitrofen (50 WP)	1	4 1/	7.94	31.76	12.00	63.76	
							107.88	5,910
Michigan, Ohio	CDAA (20G) + chloropropham (20 G)	4 + 4	1	5.45 + 4.75	40.80	8.00	48.80	
	nitrofen (4 EC)	1	4 1/	6.93	27.72	12.00	59.72	
							108.52	1,970
								19,857

1/ This assumes that Michigan and Ohio have a Special Local Need Registration which allows for multiple application of nitrofen.

Source: USDA/EPA/States, 1980

Table 2. Per Acre Cost of Alternative Weed Control Programs Used on Muck Soil Onions of New York, Michigan, and Ohio

ate	Herbicide Program	Application Rate Per Acre (Lb. of A.I.)	Number of Applications Per Season	Herbicide Cost Per Lb. of A.I. ($)	Herbicide Cost Per Acre ($)	Application Cost Per Acre ($)	Herbicide + Application Cost Per Acre ($)	Number of Acres Treat
w York	CDAA (20G)+chloropropham (20G)	4 + 4	4	5.45 + 4.75	163.20	32.00	195.20	11,967
chigan, Ohio	CDAA (20G)+chloropropham (20G)	4 + 4	4	5.45 + 4.75	163.20	32.00	195.20	1,970
chigan, Ohio	CDAA (4EC)+chloropropham (4EC)	4 + 4	4	4.94 + 4.09	144.48	32.00	176.48	5,910
								19,847

urce: USDA/EPA/States, 1980

This represents an increase of about $68.60 to $82.64 per acre in herbicide costs. The number of supplemental mechanical cultivations and hand hoeings used would be expected to remain unchanged (USDA/EPA/States, 1980).

Based on 1976 budget costs for growing onions in New York (Snyder, 1977), an increase of $68.60 to $82.64 per acre in herbicide costs would represent an eight to nine percent increase in total growing costs for growers in New York (Budget estimates were unavailable for onions grown in Michigan and Ohio). For the average onion grower in New York, Michigan, or Ohio with about 50 acres (USDA/EPA/States, 1980), the change from nitrofen to alternative herbicide programs would increase production costs by about $3,430 to $4,132 per season.

The use of alternative herbicides on the 19,847 acres of muck soil onions would increase annual production costs by about $1.6 million per season (Table 3).

<u>Mineral Soils</u> (Arizona, California, Colorado, Idaho, New Mexico, New York, Oregon, Texas, Utah and Washington)

Approximately 100,000 acres of onions (1977-79 annual average) are grown on mineral soils in Arizona, California, Colorado, Idaho, New Mexico, New York, Oregon, Texas, Utah and Washington (USDA/EPA/States, 1980). Of this total acreage, an estimated 38,879 acres (39 percent of total planted acreage) are treated with nitrofen (Table 4). Less than 13 percent of the California acreage, 100 percent of the New York acreage and 50 percent of the acreage in the remaining states receive nitrofen treatments.

Table 3. A comparison of Costs for Weed Control on Onions Grown on Muck Soils, With and Without Nitrofen

With Nitrofen				Without Nitrofen			
Nitrofen Programs Cost Per Acre 1/ ($)		Acres Treated 1/	Total Cost ($)	Alternative Programs Cost Per Acre 2/ ($)		Acres Treated 2/	Total Cost ($)
112.56		8,975	1,010,226	195.20		13,937	2,720,502
107.88		5,910	637,571	176.48		5,910	1,042,997
108.52		4,962	538,476		Total	19,847	3,763,499
	Total	19,847	2,186,273				

Annual Cost of Alternative Programs:	$3,763,499
Annual Cost of Nitrofen Programs:	$2,186,273
Increase in Annual Production Costs:	$1,577,226

1/ See Table 1.
2/ See Table 2.

Source: USDA/EPA/States, 1980.

Table 4. Mineral Soil Onions: Total 1977-79 Average Acres Planted and Number of Acres Treated with Nitrofen by State

State	Acres Planted	Treated Acreage: Acres	Treated Acreage: % of States acreage
Arizona	1,700	850	50
California	32,900	4,113	12.5
Colorado	7,967	3,983	50
Idaho	5,100	2,550	50
New Mexico	3,767	1,883	50
New York	2,500	2,500	100
Oregon	9,467	4,733	50
Texas	30,433	15,217	50
Utah	2,000	1,000	50
Washington	4,100	2,050	50
Total	99,934	38,879	39

Source: USDA/EPA/States, 1980.

The typical weed control strategy identified by the USDA/EPA/States Assessment Team for all the states listed includes using nitrofen in sequence with a preemergence and a layby application of DCPA (10 pounds a.i. per acre per application). Nitrofen is applied when the crop is at the 2-3 leaf stage. In addition to herbicide treatments, weed control programs usually include mechanical cultivations and at least one stand up hand hoeing per season. Other herbicides are used in sequence with nitrofen and DCPA but their availability is often restricted.

Texas and New Mexico

The 17,100 treated mineral soil onion acres in Texas and New Mexico (Table 4) receive a preplant soil incorporated application of bensulide in addition to the two DCPA and one nitrofen applications. (Bensulide is registered for use on onions in Texas and New Mexico only, EPA 1980). The cost of this herbicide program is estimated to be about $177.19 per acre. If nitrofen were no longer available for use on onions in Texas and New Mexico, growers would not be expected to increase the number of DCPA and bensulide applications but an additional 10 hours of hand hoeing ($3.15/hour) would be required (USDA/EPA/States, 1980). The cost of the alternative program is estimated to be $168.93 per acre, a cost reduction of $8.26 per acre. The total cost of the alternative program is $2,888,703 (assuming all 17,100 acres are impacted), a reduction in production costs of $141,246 (Table 5).

Table 5. Cost of Oxyfluorfen and Alternative Weed Control Programs Used on Mineral Soil Onions in Texas and New Mexico.

Weed Control Program	Treated Acres	Application Rate/Acre (lbs. a.i.)	Number of Applications a/	Herbicide Cost ($/lb. a.i.)	Herbicide Cost Per Acre ($/acre)	Application Cost b/ ($/acre)	Additional Hand Hoeing Cost ($/acre)	Weed Control Cost/Acre ($/acre)	Total Weed Control Cost ($)
Oxyfluorfen Sequence									
Bensulide	17,100	4.5	1	5.74	25.83	17.00		42.83	732,393
DCPA	17,100	10.0	2	3.93	78.60	16.00		94.60	1,617,660
Oxyfluorfen	17,100	4.0	1	7.94	31.76	8.00		39.76	679,896
								177.19	3,029,949
Alternative Sequence									
Bensulide	17,100	4.5	1	5.74	25.83	17.00		42.83	732,393
DCPA	17,100	10.0	2	3.93	78.60	16.00		94.60	1,617,660
Handweeding	17,100	10 hours	1	3.15/hour	–		31.50	31.50	538,650
								168.93	2,888,703
Net Decrease								8.26	141,246

a/ Bensulide is incorporated preplant, DCPA is applied preemergence and layby and oxyfluorfen is applied postemergence.
b/ Soil incorporation costs $17.00/application per acre, spray application costs $8.00/application per acre.

Source: USDA/EPA/States, 1980

California

Along with nitrofen and DCPA, the herbicides registered for use on mineral soil onions in California include chloroxuron, dinoseb and sulfuric acid (Table 6). A wide spectrum of weeds occur in onion fields and none of the registered herbicides control all the weed species. Depending on the availability of the herbicide and the weed problems, growers may use all or none of the herbicides listed in sequence with nitrofen and DCPA. Dinoseb, chloroxuron and, to some extent, sulfuric acid, are not available to all growers in the state. Dinoseb is registered for onions by Dow Chemical Company only in Santa Clara, Monterey and San Benito Counties (EPA, 1980). It can only be used early in the season and under certain temperature conditions (not used if temperature is 85°F or higher). Chloroxuron is available only to growers who contract with Basic Vegetable Products Incorporated, which has its own label for use on onions (Rowe, 1980). Approximately 26 percent of all California onion growers contract with Basic. Sulfuric acid is hazardous, requires special application equipment and is not available in all areas of the state (Rowe, 1980).

The following herbicide program for mineral soil onions is suggested by the University of California (Rowe, 1980) and is identified by the USDA/EPA/States Assessment Team as a typical weed control strategy for California:

Post plant, preemergence:	DCPA
Postemergence:	nitrofen, sulfuric acid, chloroxuron
Layby:	DCPA

Table 6. Rates of Application and Costs of Herbicides Registered for Use as Weed Controls on Mineral Soil Onions in California

Herbicide	Application Rate/Acre (lbs. a.i.)	Timing of Application	Herbicide Cost/ Pound A.I. ($/lb.a.i.)	Herbicide Cost/ Acre ($/acre)	Application Cost/Acre ($/acre)	Total Weed Control Cost ($/acre)
Nitrofen	4	postemergence	7.94	31.76	8.00	39.76
DCPA	10	preemergence and layby	3.93	39.30	8.00	47.30
Sulfuric Acid a/	10 gals.	postemergence	N/A	N/A	N/A	50.00
Chloroxuron b/	3	postemergence	6.70	20.10	8.00	28.10
Dinoseb c/	1	postemergence	17.10	17.10	8.00	25.10

a/ Hazardous, requires special application equipment and is not available in all areas of California. Set price of $50.00 per application per acre for material and application.

b/ Chloroxuron is available only to growers who contract with Basic Vegetable Products, Inc.

c/ Only registered for San Benito, Santa Clara and Monterey Counties.

Source: USDA/EPA/States, 1980. EPA, 1980.

All of the herbicides are not necessarily applied. It depends on the weed population, weed species, timing of weed germination and the availability of the herbicides. There are a number (unknown) of mechanical cultivations during the season and most onion fields have a hand hoeing crew walk through the field at least once per season (Rowe, 1980).

A list of weed control programs for onions without nitrofen identified by the USDA/EPA/States Assessment Team is presented in Table 7. Alternative programs suggest various combinations of the registered herbicides DCPA, chloroxuron, dinoseb and sulfuric acid. Any one of these combinations could also be used in a nitrofen weed control program. Due to the unavailability of detailed biological data, this analysis assumes a grower would use the same combination of herbicides without nitrofen as he currently uses with nitrofen. Therefore, the only difference in the alternative program would be the omission of nitrofen and the additional hand hoeing (10 hours) and cultivation. The change in the production cost is determined by the cost of nitrofen no longer incurred and the cost of the additional hand hoeing and cultivation (Table 8). The material and application cost of the nitrofen which the grower would no longer incur is about $39.76 per acre or $163,533 for all acres impacted (4,113 acres). The per acre cost for the additional cultivation ($15.00/acre) and the hand hoeing ($72.80/acre) is estimated to be $87.80, the total cost is $361,121. The change in production costs resulting from a change to an alternative weed control program is a net increase of $197,588 if all 4,113 acres are impacted.

Preemergence:	DCPA	DCPA	DCPA	DCPA	DCPA	DPCA	DPCA
Postemergence:	Sulfuric Acid DCPA Chloroxuron	Sulfuric Acid Chloroxuron	Sulfuric Acid Chloroxuron	Dinoseb Chloroxuron	Dinoseb Chloroxuron	Sulfuric Acid	Chloroxuron
Layby:	DCPA	DCPA		DCPA		DCPA	DCPA
Operations 1/	1 additional hand hoeing	1 additional hand hoeing	1 additional hand hoeing 1 additional cultivation	1 additional hand hoeing 1 additional cultivation	1 additional hand hoeing 1 additional cultivation	1 additional hand hoeing	1 additional hand hoeing 1 additional cultivation

1/ These operations are in addition to those performed in a nitrofen control program.

Source: USDA/EPA/States, 1980.

Table 8. Additional Costs of Alternative Weed Control Program for Mineral Soil Onions In California.

	Acres Treated	Cost Per Acre ($/acre)	Total Cost ($)
Alternative Program a/			
Additional Cultivation	4,113	15.00 b/	61,695
Additional Hand Hoeing	4,113	72.80 c/	299,426
Total		87.80	361,121
Less Nitrofen Cost No Longer Incurred	4,113	39.76 d/	163,533
Net Cost Increase		48.04	197,588

a/ An alternative program includes various combinations of other herbicides registered for use on onions e.g. chloroxuron, DCPA, dinoseb, and sulfuric acid. These herbicides are currently used in sequence with nitrofen. With detailed biological data lacking, it is assumed that the only difference between a nitrofen weed program and an alternative program without nitrofen is 1 additional hand hoeing and 1 additional cultivation.

b/ Mechanical cultivation costs for onions in California were not available. The $15.00 cost is the per acre cost of each mechanical cultivation of carrots and parsley ~~(Preliminary Benefit Analysis of Parsley and Carrots~~ EPA, 1980, ~~Draft).~~

c/ An additional 10 hours of hoeing per acre is required without nitrofen at $7.28/hour.

d/ Application rate of nitrofen is 4 pounds a.i. per acre at $7.94/pound a.i. or $31.76/acre. The cost also includes a per acre application cost of $8.00/application.

Source: USDA/EPA/States Assessment Team, 1980.

Arizona

In Arizona, the typical weed control program of nitrofen in sequence with DCPA sometimes includes an application of sulfuric acid. Sulfuric acid is registered for use on onions in Arizona and California but the amount of sulfuric acid used in Arizona is not known. Growers not currently using sulfuric acid in sequence with nitrofen and DCPA may include an application of sulfuric acid if nitrofen is not available. This alternative program may or may not require an additional hand hoeing. If growers currently use sulfuric acid in sequence with nitrofen and DCPA or if they cannot feasibly apply it, the only alternative would be additional hand hoeing. Due to the lack of data on weed control programs in Arizona, the analysis assumes that, in addition to current DCPA applications, onion growers would include one of the following programs: (1) sulfuric acid and 10 additional hours of hand hoeing; (2) sulfuric acid; or (3) 10 additional hours of hand hoeing. Production cost changes would range from a decrease of $7.26 to an increase of $42.74 per acre or a decrease of $6,171 to an increase of $36,329 for the total 850 impacted acres (Table 9).

New York

In New York, DCPA is used on all mineral soil onion acreage at preemergence and again at a later stage of growth at least once (USDA/EPA/States, 1980). Nitrofen is applied to all mineral soil onion acreage 2 to 3 times at 0.5 to 1.0 pound a.i. per acre. The only

Table 9. Comparative Weed Control Costs on Mineral Soil Onions In Arizona, With and Without Nitrofen.

Weed Control Program	Acres Treated	Weed Control Cost/Acre ($/acre)	Total Weed Control Cost ($)	Net Cost Difference from Nitrofen Progam/acre ($/acre)	Total Net Cost Difference from Nitrofen Program ($)
Nitrofen Program					
Nitrofen	850	39.76 a/	33,796	-	-
Alternative Program					
Sulfuric Acid	850	50.00 b/	42,500	10.24	8,704
Hand Hoeing	850	32.50 c/	27,625	- 7.26 d/	- 6,171 d/
Sulfuric Acid +	850	50.00	42,500		
Hand Hoeing	850	32.50	27,625		
		82.50	71,230	42.74	36,329

a/ Application rate of 4 pounds a.i. per acre at $7.94/pound a.i. or $31.76/acre. The cost also includes an application cost of $8.00/application.

b/ Cost includes material cost and cost of application.

c/ Without nitrofen an estimated 10 additional hours of hand hoeing are required at a cost of $3.25/hour. This cost is the wage rate for field workers (Jan., April, 1980) as reported in Farm Labor; ESCS, USDA May, 1980.

d/ Represents a decrease in cost.

Source: USDA/EPA/States Assessment Team, 1980.

alternative without nitrofen is 4 cultivations and 4 (30 hours/acre) hand hoeings in addition to the current program (USDA/EPA/States, 1980). The use of this alternative weed control strategy in place of nitrofen would increase production cost by an estimated $537.09 per acre (Table 10). If this alternative program were used on all the 2,500 acres impacted in New York, total production costs would increase by $1,342,725 per year.

Colorado, Idaho, Oregon, Utah and Washington

In Colorado, Idaho, Oregon, Utah and Washington, nitrofen is usually applied in sequence with DCPA for weed control on mineral soil onions (USDA/EPA/States, 1980). Based on the limited data available, there appear to be no registered chemical alternatives for nitrofen. The alternative program assumed for this analysis would be identical to the nitrofen program, except there would be no nitrofen applied and 10 additional hours of hand hoeing would be required (USDA/EPA/States, 1980). Table 11 presents changes in production cost resulting from the unavailability of nitrofen. The use of the alternative weed control program on all the impacted acreage in the 5 states (14,316 acres) would decrease production costs by $90,263.

Total Mineral Soil Acreage

Summing the production cost changes derived for Arizona, California, Colorado, Idaho, New Mexico, New York, Oregon, Texas, Utah and Washington results in a total cost increase of $1,302,633 to $1,345,133 for all mineral soil onion acreage treated with nitrofen (Table 12).

Table 10. Additional Costs of Alternative Weed Control Program for Mineral Soil Onions in New York.

	Acres Treated	Cost Per Acre ($/acre)	Total Cost ($)
Alternative Program a/			
Additional Cultivation	2,500	25.00 b/	62,500
Additional Hand Hoeing	2,500	540.00 c/	1,350,000
Total		565.00	1,412,500
Less Nitrofen Cost No Longer Incurred	2,500	27.91 d/	69,775
Net Cost Increase		537.09	1,342,725

a/ The nitrofen weed control program includes nitrofen used in sequence with multiple applications of DCPA, hand hoeings and cultivation. Without nitrofen, the alternative program does not require any additional applications of DCPA but does require 4 additional hand hoeings and 4 additional cultivations (USDA/EPA/States, 1980).

b/ The estimated 4 additional cultivations costs $6.25/cultivation per acre without nitrofen.

c/ Without nitrofen an estimated 4, 30 hour cultivations are required at a cost of $4.50/hour (USDA/EPA/States, 1980).

d/ In New York, 1-3 applications of nitrofen at a rate of 0.5 to 1.0 pound a.i. per acre is used on mineral soil onions. The cost in the table assumes an average of 2 applications per acre at $8.00/application and an average rate of .75 pounds a.i. per application at a cost of $7.94/pound a.i ($11.91/acre for 2 applications).

Source: USDA/EPA/States Assessment Team, 1980.

Table 11. Additional Costs of Alternative Weed Control Programs Used on Mineral Soil Onions in Colorado, Idaho, Oregon, Utah and Washington.

State	1977-79 Average Treated Acres 1/	Additional Hours of Hand Hoeing 1/	Cost per Hour ($/hour) 2/	Cost per Acre ($/acre)	Total Cost ($)
Colorado	3,983	10	2.99	29.90	119,092
Idaho	2,550	10	3.34	33.40	85,170
Oregon	4,733	10	3.33	33.30	157,609
Utah	1,000	10	4.04	40.40	40,400
Washington	2,050	10	3.74	37.40	76,670
Total	14,316				478,941
Less nitrofen cost no longer incurred	14,316			39.76	569,204
				Net Cost Decrease	90,263

1/ USDA/EPA/States, 1980.
2/ Hourly wage rate of field workers (July 11-18, 1980) as reported by Farm Labor, ESCS, USDA Nov. 1980.

Table 12. Production Cost Change for Total Mineral Soil Onion Acreage Treated.

State	1977-79 Average Acreage Treated	Change in Production Cost 1/ Without Nitrofen ($)
Arizona	850	-6,171 to +36,329
California	4,113	+197,588
Colorado	3,983	-39,272
Idaho	2,550	-16,218
New Mexico	1,883	-15,554
New York	2,500	+1,342,725
Oregon	4,733	-30,575
Texas	15,217	-125,692
Utah	1,000	+640
Washington	2,050	-4,838
Total Cost Increase +1,302,633 to +1,345,133		

1/ See Tables 2, 5, 6, 7 and 8. A minus (-) sign indicates a decrease in cost, a plus sign (+) indicates an increase.

Impact on Output and Revenue

Muck Soils

In addition to increased production costs, some onion growers using alternative herbicides would also incur yield losses on their treated acreage. Multiple applications of the alternative herbicides (CDAA and chloropropham) in the emulsifiable concentrate formulation would be expected to reduce yields on muck soils by an estimated 10 to 15 percent due to problems of phytotoxicity (USDA/EPA/States, 1980). In Michigan and Ohio where the emulsifiable concentrate would be used, these yield losses would be expected on about 75 percent of the treated acreage (5,910 acres). In New York where growers would use the granular formulation, no yield losses would be expected on the treated acreage[1/].

Yield losses on the affected acreage in Michigan and Ohio would reduce the annual output of onions by about 195 to 292 thousand cwt. (Table 13). At current prices (1977-79 annual average), this output reduction would represent an annual revenue loss of about $1.1 to 1.6 million for the affected growers (Table 13)[2/].

1/ The choice of herbicide formulation appears to be based on the equipment available to growers and the specific weed problems encountered.

2/ This estimate of revenue loss may be biased upwards because it is based on the assumption that current prices would remain constant. In actuality, the reduced suppply of onions may cause prices to rise and thereby offset some or all of the revenue loss due to yield reductions on the affected acreage.

Table 13. Estimated Output Reduction of Muck Soil
Onions Resulting from Use of Alternative Herbicide Program

State	Nitrofen Treated Acreage	1977-79 Avg. Yield Per Acre (cwt)	10-15 Percent Yield Reduction Per Acre (cwt)	Affected Acres 1/	Output Reduction (cwt)	Value Per Cwt. (1977-79 Average) ($)	Revenue Loss to Affected Growers ($)
Michigan	7400	325	32.5 - 48.8	5,550	180,375 - 270,840	5.59	1,008,296-1,513,996
Ohio	480	393	39.3 - 59.0	360	14,148 - 21,240	5.94	84,039- 126,166
			Total	5,910	194,523 - 292,080		1,092,335-1,640,162

1/ 75 percent of the nitrofen treated acreage assumed to be treated with alternative herbicides in the emulsifiable concentrate formulation which would reduce yields by an estimated 10 to 15 percent.

Source: USDA, Vegetables. 1979 Annual Summary, 1980.
USDA/EPA/States, 1980.

Mineral Soils

The use of alternative weed control programs on mineral soil onions would also be expected to cause yield losses. Without nitrofen, 20 percent yield losses are expected in Texas and New Mexico and a 15 percent loss is expected in New York (USDA/EPA/States, 1980). Due to the lack of data for the remaining states, a 20 percent reduction in yield is assumed.

Table 14 presents reduction in yields and revenue losses by state and by crop (spring, summer non-storage and summer storage). Yield losses on the effected acreage in all 11 states would reduce annual output by about 2,293 thousand hundred weight (Table 14). At current prices (1977-79 annual average), this reduction in output would represent a total annual revenue loss of about $17.8 million dollars (Table 14).

Impact on Net Farm Income

Assuming that labor costs and market prices for onions will not change, the reduction in net farm income is estimated to range from $18.8 to $18.9 million for mineral soil onions and $2.7 to $3.2 million for muck soil onions. The total reduction in net farm income for all impacted onion acreage ranges from $21.5 to $22.1 million (Table 15).

Table 14. Estimated Output and Revenue Losses of Mineral Soil Onions Resulting from Use of an Alternative Weed Control Program

Quarter and State	Total Nitrofen Treated Acres a/ (Mineral Soil)	Yield Per Acre a/ (cwt.)	Yield Reduction Per Acre b/ (cwt.)	Total Yield Reduction (cwt.)	Value Per Cwt. a/ Dollars	Total Revenue Loss (Dollars)
Spring						
Arizona	850	395	79	62,900	7.21	484,151
California	699 c/	328	66	46,134	8.80	405,979
Texas	11,413 c/	158	32	365,216	10.64	3,885,898
Total	12,972			474,250		4,776,028
Summer Non-storage						
New Mexico	1,883	315	63	188,629	9.11	1,080,710
Texas	3,804 c/	223	45	171,180	10.82	1,852,168
Washington	390 c/	363	73	28,470	10.30	293,241
Total	6,077			318,279		3,226,119
Summer Storage						
California	3,414 c/	322	64	218,496	5.13	1,120,884
Colorado	3,983	325	65	258,895	6.48	1,677,640
Idaho	2,550	480	96	244,800	6.92	1,694,016
New York	2,500	315	47	177,500	7.84	921,200
Oregon (east)	3,597 c/	495	99	356,103	6.92	2,464,233
Oregon (west)	1,136 c/	440	88	99,968	6.14	613,804
Utah	1,000	370	74	74,000	5.93	438,820
Washington	1,660 c/	397	79	131,140	6.62	868,147
Total	19,840			1,500,902		9,798,744
U.S.	38,879			2,293,431		17,800,891

a/ 1977-79 average estimated from Vegetables 1979 Annual Summary Acreage, Yield, Production and Value (USDA 1980).

b/ A 15% yield loss is expected for New York and a 20% yield loss is expected for all other states affected.

c/ The allocation of nitrofen treated acreage by season is assumed to be in the same proportion as the total state acreage. For example, if 75 percent of Texas' total acreage is allocated in the Spring crop, it is assumed that the same percentage of its treated acreage is also allocated to the Spring crop.

Table 15. Short Run Economic Impact to Onion Growers Substituting Alternative Weed Control Programs for Nitrofen Programs

	Change in Production Cost a/ ($)	Total Revenue Loss b/ ($)	Net Farm Income Loss ($)
Mineral Soil Onions			
Arizona	-6,171 to +36,329	484,151	477,980-520,480
California	+197,588	1,526,863	1,724,451
Colorado	-39,272	1,677,640	1,487,591
Idaho	-16,218	1,694,016	1,677,798
New Mexico	-15,554	1,080,710	1,065,156
New York	+1,342,725	921,200	2,263,925
Oregon	-30,575	3,078,037	3,047,462
Texas	-125,692	5,738,066	5,612,374
Utah	+640	438,820	439,460
Washington	-4,838	868,147	863,309
Total Mineral Soil	+1,302,633 to +1,345,133	17,507,650	18,810,283 - 18,852,783
Muck Soil Onions			
Michigan	+ 541,088	1,008,296-1,513,996	1,549,384-2,055,084
New York	+1,001,040	0	1,001,040
Ohio	+ 35,098	84,039- 126,166	119,137- 161,264
Total Muck Soil	+1,577,226	1,092,335-1,640,162	2,669,561-3,217,388
Total	+2,879,859 to +2,922,359	18,599,985-19,147,812	21,479,844-22,070,171

a/ See Tables 3 and 12.
b/ See Tables 13 and 14.

Potential Acreage Shifts

If net farm incomes are seriously impacted as a result of the regulatory action on nitrofen, onion growers may shift acreage to other crops in the long run. Growers would likely shift their acreage to crops currently rotated with onions. These crops would vary by state and by type of soil. In Texas and New Mexico, for example, onion growers would reallocate their impacted acreage to rotation crops such as cabbage, cotton, cantaloupe, carrots, and peppers (USDA/EPA/States, 1980).

Market and Consumer Impacts

The use of alternative weed control programs in place of nitrofen programs would reduce the short run supply of onions by an estimated 2.5 to 2.6 million cwt., a reduction of about 7 percent in the 1977-79 average annual output (USDA, 1980). This short run reduction in supply would be expected to push up prices at the grower and retail market levels. However, the lack of data on price elasticities of demand and supply prevents an estimation of the magnitude of the potential price increases at the grower and retail levels.

In the long run, higher prices at the grower level would be expected to stimulate new and expanded production which would increase the supply of onions and reduce the initial impact on retail prices and supply.

Macroeconomic Impacts

The macroeconomic impacts of cancelling nitrofen use on onions are expected to be negligible.

Social/Community Impact

Although data limitations prevent an in-depth evaluation of the social and community impacts of nitrofen suspension, several potential impacts may be noted:

1. Additional hoeing operations and mechanical cultivations required by alternative weed control programs would increase the seasonal demand for field labor and possibly bid up current wages. In some areas there could be seasonal shortages of field labor.

2. The use of alternative weed control programs or the reallocation of land to other crops could lead to an increased demand for new farm equipment and other factors of production.

3. The short run reduction of onion production could cause some local processors to operate at a less than optimum level of output. In some cases, processors might need to search out new, and more distant supplies of onions or reinvest in new capital capable of processing alternative crops.

Limitation of Analysis

1. A number of simplifying assumptions were made throughout the analysis due to incomplete biological data. Specific data problems were encountered with the specification of nitrofen and alternative weed control programs relevant to mineral soil onion production.

2. Detailed yield loss data for mineral soil onions in Arizona, California, Colorado, Idaho, Oregon, Utah and Washington were not available. A 20 percent yield loss was assumed for these states, which is analogous to the 20 percent yield loss identified for Texas and New Mexico (USDA/EPA/States, 1980).

3. The cost of hand hoeing labor for onions in California, Michigan, New York, Ohio, Texas and New Mexico were identified by the USDA/EPA/States Assessment Team. For the remaining states, the hand hoeing costs were based on field worker wages reported in the USDA Farm Labor Reports of May and November, 1980. The labor costs for all states were assumed to remain constant in the short run.

4. It was assumed that adequate supplies of labor for additional hoeing operations and mechanical cultivations were available.

5. The mechanical cultivation cost for mineral soil onions in California was not available. An assumed $15.00 per acre

cultivation cost was based on the mechanical cultivation costs for the carrot and parsley nitrofen use sites.

6. The impacts upon other production practices (e.g. modification of harvesting equipment), as affected by alternative weed control programs, were not specified.

7. Price elasticities of demand and supply were unavailable; the farm level prices of onions were assumed constant.

8. Biological and economic data were insufficient for long run estimates of potential onion acreage shifts if nitrofen were suspended.

References

Rowe, Gordon and Barbara Albertson. Tok (Nitrofen), Cultural Practices for Crops and Economic Impacts (Draft). Cooperative Extension. University of California. Berkeley, California. July 1980.

Snyder, Darwin P. Cost of Production Update for 1976, Muck Onions of Orange County, New York. Cornell University Agricultural Experiment Station. Ithaca, New York. June, 1977.

U.S. Department of Agriculture. Farm Labor. ESCS, Crop Reporting Board. Washington, D.C. May and November, 1980.

U.S. Department of Agriculture. Vegetables - 1979. Annual Summary, Acreage, Yield, Production, and Value. ESCS, Crop Reporting Board. Washington, D.C. June, 1980.

U.S. Department of Agriculture. U.S. Environmental Protection Agency and State Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen. Washington, D.C. 1980.

U.S. Environmental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. July, 1980.

PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON PARSLEY

. USE: Parsley

. MAJOR PESTS CONTROLLED: Annual bluegrass, crabgrass, goosefoot, lambsquarter, malva, nightshade, nettle, pigweed, purslane, shepherdspurse, spergularia.

. ALTERNATIVES:

Major registered chemicals: Petroleum distillate and linuron (Florida only).

Non-chemical controls: Mechanical cultivation and hand hoeing.

Comparative performance: Fresh parsley yield losses of 20 percent are expected in Florida with the linuron control program. For parsley grown in other areas, 25 percent yield losses are expected with the petroleum distillate control programs.

Comparative costs:

State/Region	Nitrofen Program Costs/Acre	Alternative Program Costs/Acre	Cost Difference
California, Midwest	$65.72-$135.72	$339.00-$434.00	$273.28-$298.28
Texas	283.22	697.50- 722.50	414.28- 439.28
New Jersey	283.22	751.50- 776.50	468.28- 493.28
Florida	323.62	731.50	407.88

All states and regions, except Florida, will use petroleum distillate; Florida will use linuron in the alternative program. Alternative control costs for Texas, New Jersey and Florida include allowances for additional hand harvesting labor for fresh market parsley.

D. EXTENT OF USE: All of the 2,650 U.S. commercial acres of parsley are estimated to be treated with 10,600 lb. A.I. nitrofen.

State/Region	Total Acres Treated	Percent	Total Pounds A.I.	Percent
California	800	30.2	3,200	30.2
Midwest	200	7.6	800	7.6
Texas, New Jersey	520	19.6	2,080	19.6
Florida	1,130	42.6	4,520	42.6
Total	2,650	100.0	10,600	100.0

E. ECONOMIC IMPACTS:

User: Increased production costs per acre will range from $273 to $298 (18.1 to 19.8 percent) for processing parsley and from $408 to $493 (12.4 to 15.0 percent) for fresh parsley. The total cost increase will range from $949,610 to $1,015,690. Total cost increases by states/region are: California - $218,624 to $238,624; Midwest - $54,656 to $59,656; Texas, New Jersey - $215,426 to $256,506; and Florida - $460,904.

Total output losses are estimated as 2,500 tons of processing parsley and 14.24 million bunches of fresh parsley.

Short term annual farm income losses range from $1,398 to $1,423 per acre for processing parsley (California and Midwest) and from $1,742 to $2,160 per acre for fresh parsley (Texas, New Jersey and Florida). The total annual short term income loss ranges from $4.45 to $4.51 million. Short term net income losses by states/region are: California - $1,118,400 to $1,138,400; Midwest - $279,600 to $284,600; Texas, New Jersey - $1,082,120 to $1,123,200; and Florida - $1,968,460.

In the longer term, increased parsley production in nonimpacted areas could reduce market prices and impacted growers' income. About 25 percent of the impacted acres could shift to kale, mustard and endive.

Consumer: The 20 to 25 percent reduction in U.S. parsley output would increase short term retail prices. Though not quantified, prices at the retail level would be expected to increase at a lower rate than at the farm level.

Macroeconomic: Macroeconomic impacts are expected to be either negligible or nonexistent.

F. SOCIAL/COMMUNITY IMPACTS: Increased employment for farm labor is expected in the short term. Longer term shifts to alternative crops may create excess capacity for parsley processors and increase capital requirements for new crop production equipment.

G. LIMITATIONS OF THE ANALYSIS: Due to a lack of experimental data, yield losses and other biological information were based mostly on professional judgement. Limited economic information was available on price elasticities, enterprise budgets, and comparative returns for alternative uses of farm resources. Short term farm output prices were assumed constant and labor supplies were assumed readily available at existing wage rates.

H. PRINCIPAL ANALYST AND DATE:

H. W. Gaede
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
January 1981

Preliminary Benefit Analysis of Nitrofen Use on Parsley

Current Use Analysis

EPA Registrations of Nitrofen and Alternatives

Nitrofen formulated as a 25EC is registered as a weed control for annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, shepherdspurse and spergularia in parsley. One pre- or postemergence spray application of 2 to 6 pounds AI mixed in 40 to 60 gallons of water is the labeled rate per acre application (EPA, 1980).

Other EPA registered herbicides for use on parsley include petroleum distillate and linuron (Florida only).

Use of Nitrofen and Alternatives

Nitrofen usage of 10,600 pounds AI was applied to all of the 2,650 acres of parsley produced in the U.S. (Table 1). Nitrofen treatments of parsley grown for the processing market are typically supplemented with two mechanical cultivations; hand hoeing (0-20 hours per acre) may or may not be used. For fresh market parsley, nitrofen treatments are usually combined with 6 mechanical cultivations and 45 hours of hand hoeing per acre (USDA/EPA/States, 1980).

Table 1. Use of Nitrofen and Alternatives on Parsley

Nitrofen and Alternative Treatments	Total Treated Acres	Total Pounds AI Applied	Number of Applications	Pounds AI Per Acre Applications	Number of Mechanical Cultivations	Number of Hand Hoeing Hours	Other Changes Affecting Production Costs	Percent Cha in Output Per Acre
California a/								
Nitrofen (preemergent)	800	3,200	1	4	2	0-20	—	—
Petroleum distillate	800	96,000-144,000 gal.	3	40-60 gal.	6	50-70	c/	25
Midwest a/								
Nitrofen (preemergent)	200	800	1	4	2	0-20	—	—
Petroleum distillate	200	24,000-36,000 gal.	3	40-60 gal.	6	50-70	c/	25
Texas, New Jersey b/								
Nitrofen (preemergent)	520	2,080	1	4	6	45	—	—
Petroleum distillate	520	62,400-93,600 gal.	3	40-60 gal.	11	95	d/	25
Florida b/								
Nitrofen (preemergent)	1,130	4,520	1	4	6	45	—	—
+ Linuron (postemergent)	1,130	3,390	1	3				
Linuron (pre and postemergent)	1,130	5,650	2	3+2	11	95	d/	20

a/ Parsley production for the processing market.
b/ Parsley production for the fresh market
c/ Irrigation costs may increase slightly for parsley replanted in the summer. A small proportion of the processed parsley acreage may be replanted after two cuttings because of heavy weed infestations (USDA/EPA/States, 1980).
d/ Hand harvesting labor requirements for fresh parsley are estimated to increase by 15 percent (USDA/EPA/States, 1980).

Without nitrofen, parsley growers would be limited to the use of petroleum distillate and linuron (Florida only). For all states other than Florida, parsley producers would substitute three applications of petroleum distillate (40-60 gallons/acre application) and would increase both the number of mechanical cultivations (4 to 5 additional cultivations) and hand weeding (50 additional hours/acre). In Florida, the nitrofen program would be replaced with pre- and postemergent linuron treatments (3 + 2 lb. AI/per acre) plus five additional mechanical cultivations and 50 additional hours of hand weeding per acre (Table 1).

Yield losses associated with the alternative weed control programs are estimated as 20 percent in Florida and 25 percent in all other states (USDA/EPA/States, 1980).

Economic Impact Analysis

Production Cost Changes

Based upon information presented in Table 1, the nitrofen weed control costs for processed parsley grown in California and the Midwest would range from $65.72 to $135.72 per acre (Table 2). For fresh parsley production, the nitrofen weed control programs would cost from $283.22 (Texas and New Jersey) to $323.62 (Florida) per acre.

Table 2. Production Costs Impacts Per Acre of a Nitrofen Suspension on U.S. Parsley

Nitrofen and Alternative Treatment	Pesticide Material Cost c/ (dollars)	Pesticide Application Costs d/ (dollars)	Mechanical Cultivation Costs e/ (dollars)	Hand Hoeing Costs f/ (dollars)	Other Costs (dollars)	Total Treatment Cost (dollars)
California, Midwest a/						
Nitrofen (preemergent)	27.72	8.00	30.00	0- 70.00	—	65.72-135.72
Petroleum distillate	50.00-75.00	24.00	90.00	175.00-245.00	g/	339.00-434.00
difference	22.28-47.28	16.00	60.00	175.00	g/	273.28-298.28
Texas, New Jersey b/						
Nitrofen (preemergent)	27.72	8.00	90.00	157.50	—	283.22
Petroleum distillate	50.00-75.00	24.00	165.00	332.50	126.00-180.00 h/	97.50-776.50
difference	22.28-47.28	16.00	75.00	175.00	126.00-180.00	414.28-493.28
Florida b/						
Nitrofen (preemergent) + Linuron (postemergent)	60.12	16.00	90.00	157.50	—	323.62
Linuron (pre- and postemergent)	54.00	16.00	165.00	332.50	164.00 h/	731.50
difference	-6.12	—	75.00	175.00	164.00	407.88

a/ Parsley production for the processing market.
b/ Parsley production for the fresh market.
c/ Based upon information presented in Table 1 and the following herbicide prices: nitrofen $6.93/lb AI; petroleum distillate-$1.25/gallon; linuron-$10.80/lb AI.
d/ Spray application costs $8.00/acre application. See Table 1 for number of applications.
e/ Mechanical cultivation at slow speed costs $15.00/acre. See Table 1 for number of mechanical cultivations.
f/ Hand hoeing labor is estimated to cost $3.50/hour. See Table 1 for the number of hours.
g/ A non-quantified small proportion of the parsley acreage for processing may have to be replanted (Walton, 1980; USDA/EPA/States, 1980).
h/ Hand harvesting labor requirements for fresh parsley are estimated to increase 15 percent relative to the .4 hours/crate requirement with nitrofen. Since fresh parsley output per acre is 667 crates, hand harvesting wage rates for different states are as follows: Texas-$3.15/hour New Jersey-$4.50/hour; and Florida-$4.10/hour.

For processing parsley grown in California and the Midwest, the weed control costs for the alternative programs ranged $339 to $434 per acre (Table 2). It has been assumed that no additional costs will be associated with the few acres (quantified estimates were not available) that may need to be replanted because of heavy weed infestations.

For fresh parsley grown in Texas, New Jersey and Florida, the costs of alternative programs will range from about $698 to $777 per acre. These production costs also include an additional 40 hours (a 15 percent increase) of hand harvesting labor per acre to control the increased weediness of the fields.

Increased production costs per acre for the alternative programs will range from about $273 to $298 for processing parsley and from about $408 to $493 for fresh parsley (Table 2).

Current projections from California indicate that 1981 production costs for processed parsley with the use of nitrofen would be approximately $1,507 per acre (Walton, 1980). By using the current California estimates as a basis for comparison in the entire U.S., the $273 to $298 (see Table 2) increase in per acre weed control costs without nitrofen would represent an 18.1 to 19.8 percent increase in total production costs.

For fresh market parsley, 1980 estimates for California indicate that preharvest production costs with nitrofen are $1,285 per acre. Hand harvesting costs in California are $3 per crate and the average

yield per U.S. harvested acre is about 667 crates; hence, total per acre hand harvesting costs would be about $2,001 (USDA/EPA/States, 1980). Therefore, the total production costs per acre for fresh market parsley with nitrofen would be approximately $3,286.

By using the California production cost estimates as a basis for comparison in the entire U.S., the $408 to $493 (see Table 2) increase in per acre weed control costs would represent a 12.4 to 15.0 percent increase in the total production costs for fresh parsley. Such cost increases may lead fresh parsley growers to consider the use of mechanical harvesting as a longer term substitute for hand labor.

The total production cost increase for all impacted acres would range from $949,610 to $1,015,690. The total production cost impact is regionally disaggregated as follows:

California	$218,624 to $238,624
Midwest	$ 54,656 to $ 59,656
Texas, New Jersey	$215,426 to $256,506
Florida	$460,904

Revenue Changes

Substantital output losses are expected for all parsley acreage in the U.S. Yield losses of 20 and 25 percent are respectively estimated for 1,130 acres in Florida and 1,520 acres in all other states. Output losses are estimated as 2,500 tons of processing parsley and 14.24 million bunches of fresh market parsley (USDA/EPA/States, 1980).

The large reduction in short term output would be expected to exert strong upward pressure on all farm level parsley prices that were not held constant by contractual agreements. The magnitude of any price increase and the ramifications upon from revenue is highly speculative for the following reasons:

1. Economic measurements of changes in market prices and grower revenues often utilize price elasticity estimates of demand and supply. For both fresh and processing parsley, no price elasticity estimates were available.

2. Intuitively, the price elasticity of demand for parsley would be expected to be highly inelastic because of a few good market substitutes and the relatively small proportion of a household's budget that is committed to such purchases. However, large percentage changes in output could invalidate this premise.

For purposes of analytical simplicity, the farm level price of parsley will be assumed constant. It should be noted that this assumption will either overstate the short term loss of growers' revenue or will only be representative of an extreme worst case situation.

On a per acre basis, short term revenue losses for processing parsley were estimated as $1,125 (Table 3). For fresh market parsley, the farm revenue loss per acre would range from $1,334 in Florida to $1,667 in Texas and New Jersey.

Table 3. Short Term Revenue Changes Per Acre of a Nitrofen Suspension on U.S. Parsley

State/Regional	Farm Price/ Unit of Output a/ (dollars/unit)	Farm Output/Acre With Nitrofen	Farm Output/Acre Without Nitrofen b/	Farm Revenue/Acre With Nitrofen	Farm Revenue/Acre Without Nitrofen (dollars)	Farm Revenue/Acre Difference
California/Midwest c/	$450/ton	10 tons	7.5 tons	$4,500	$3,375	$1,125
Texas, New Jersey d/	.167/bunch	40,000 bunches	30,000 bunches	6,667	5,000	1,667
Florida d/	.167/bunch	40,000 bunches	32,000 bunches	6,667	5,333	1,334

a/ Farm price levels were assumed constant. It should be noted that this assumption will either overstate the short term loss of farm revenue or will only be representative of an extreme worst case situation.
b/ Based upon yield losses of 20 percent in Florida and 25 percent in all other areas (USDA/EPA/States, 1980).
c/ Parsley production for the processed market.
d/ Parsley production for the fresh market.

If parsley prices remained constant, the total short term loss in farm revenues would total $3,273,260 which is regionally disaggregated as follows: California - $900,000; Midwest - $225,000; Texas and New Jersey - $866,840; and Florida - $1,281,420.

In the longer term, any increase in the short term market prices would stimulate nonimpacted areas to increase production, which would cause farm prices and revenues of impacted growers to fall. The extent of longer term revenue declines to impacted growers cannot be estimated with available data.

Net Farm Income Changes

Based upon information presented in Table 4, the short term net farm income decrease would range from $1,398 to $1,423 per acre for processed parsley grown in the Midwest and California. For fresh market parsley grown in Texas, New Jersey and Florida, the decline in income would range from $1,742 to $2,160 per acre.

The short term decrease in farm income for the entire U.S. parsley industry would range from about $4.45 to $4.51 million. The total short term decrease in farm income is regionally disaggregated as follows:

California	$1,118,400 to $1,138,400
Midwest	$ 279,600 to $ 284,600
Texas, New Jersey	$1,082,120 to $1,123,200
Florida	$1,968,460

Table 4. Short Term Net Farm Income Losses Per Acre for a Nitrofen Suspension on U.S. Parsley

State/Region	Decrease in Farm Revenue/Acre a/ (dollars)	Increase in Production Costs/Acre b/ (dollars)	Decrease in Net Farm/Income/Acre c/ (dollars)
California, Midwest d/	$1,125	$273 to $298	$1,398 to $1,423
Texas, New Jersey e/	1,667	414 to 493	2,081 to 2,160
Florida e/	1,334	408	1,742

a/ See Table 3.
b/ See Table 2.
c/ Farm price levels were assumed constant. It should be noted that this assumption will either overstate the short term loss of farm revenue or will only be representative of an extreme worst case situation.
d/ Parsley production for the processed market.
e/ Parsley production for the fresh market.

The above decreases in short term income for parsley growers were based on the assumption of constant farm level prices. Since the magnitude of expected short term farm price increases could not be accurately measured with available data, the loss of growers' revenue and income are probably overstated.

In the longer term, the market supply of parsley would be expected to expand because of either increased imports or additional acreage entering production as a response to increased short term farm prices. The increased market supply would have the effect of reducing longer term prices and incomes of impacted growers. A longer term exit of impacted growers from the industry can be hypothesized, but not accurately measured; it has been estimated that 25 percent of the impacted parsley acreage would shift into the production of other greens (e.g. kale, mustard, and endive) that require less weed control effort (USDA/EPA/States, 1980).

Consumer Impacts

Short term retail price impacts cannot be accurately measured with existing data, but price increases would be expected as a response to the 20-25 percent reduction in farm output. Short term retail prices probably increase at a lower rate than those at the farm level, since farm level prices only accounted for 33 percent of the fresh vegetable and 20 percent of the processed fruit and vegetable retail prices in 1976 (USDA, 1977).

In the longer term, retail prices for parsley would be expected to fall as expanded supplies from either imports or new domestic production enter the market.

Social/Community Impacts

Data limitations preclude the accurate assessment of social/community impacts associated with a suspension of nitrofen use on parsley. However, the alternative weed control programs are expected to increase short term employment for farm workers and longer term shifts to different crops may create excess capacity for parsley processors and increase capital requirements for new crop production equipment. Any immediate social/community impacts would be expected to diminish over time.

Macroeconomic Impacts

Macroeconomic impacts are expected to be either negligible or nonexistent.

Limitations of the Analysis

1. There are insufficient biological and economic data to estimate the potential impacts of longer term crop shifts due to a nitrofen suspension.

2. The analysis assumes that adequate supplies of labor for additional hand hoeing and mechanical cultivation are available at existing wage rates.

3. Constant farm prices were used in the analysis since current price elasticiities that have relevance to a 20 to 25 percent reduction in parsley output were not available. The estimated reductions in net farm incomes would either be overstated or only representative of an extreme worst case situation.

4. Estimates for the percentage changes in parsley production costs were based on California enterprise budgets. Budgetary information for other impacted areas were not readily available.

5. Total production cost increases to replant heavily weed infested fields could not be accurately quantified. It was hypothesized that very few acres would be subject to such impacts.

6. Information on alternative weed control programs and yield losses provided by the biologists were primarily based on experience rather than experimental data.

References

U.S. Department of Agriculture, Developments in Marketing Spreads for Agricultural Products in 1976. ERS. Agricultural Economic Report Number 367. Washington, D.C. March 1977.

U.S. Department of Agriculture, U.S. Environmental Protection Agency, and State Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen. Washington, D.C. 1980.

U.S. Environmental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. July 1980.

Walton, J. Manager of Cal-Compack Foods. Personal communication. King City, California. December 5, 1980.

ECONOMIC IMPACT ANALYSIS ~~ON~~ OF NITROGEN USE ON TARO AND DAIKON

B. Ted Kuntz[1/]

The estimated economic impact of canceling ~~Tok uses on Taro~~ nitrogen use on taro and ~~D~~daikon was based on the following procedures and assumptions:

1. ~~Tok~~ nitrogen is applied once during the growing season. ~~Tok~~ nitrogen is applied as a pre-emergence incorporated treatment. Principle problem weeds controlled are ____ ____.

2. Hawaii 1977-79 average planted acreage, yield per planted acre, and value per hundredweight were used as a base for the analysis.

3. The base acreage treated with ~~Tok~~ nitrogen was estimated by agricultural scientists working in the ~~T~~taro-and ~~D~~daikon-producing areas (table 1). Only the acres currently treated are included in the analysis.

4. The alternative weed-control program was specified by agricultural scientists (table 1). This alternative program was assumed to be the best program available if ~~Tok~~ nitrogen were canceled. Market availability and efficacy of the alternatives were considered in specifying the alternative program.

1/ B. Ted Kuntz is an Agricultural Economist for the Economics and Statistics Service, Natural Resource Economics Division, U.S. Department of Agriculture, Corvallis, Oregon.

nitrogen

Table 1.--Current use and costs of ~~Tok~~ and potential alternatives for weed management in taro and daikon, Hawaii

Nitrogen and ~~A~~lternative treatment	Acres: In area[a]	Acres: Treated	Number of applications	Pound a.i.: Per acre	Pound a.i.: Total	Material cost per pound a.i. or labor cost per acre	Per acre treatment cost: Materials	Per acre treatment cost: Application	Per acre treatment cost: Total	Total cost	Change in costs using best alternative: Per acre	Change in costs using best alternative: Total
						Dollars						
Nitrogen ~~Tok~~ treatment.........	619[c]	500	1	4	2,000	7.94[b]	31.76	18.00	49.76	24,880		
Alternative treatment:	619											
Cultivation...........		500	1	--	--	10-12	--	10-12	10-12	5,000 to 6,000		
Hand hoeing...........		500	2	--	--	50-75	--	100-150	100-150	50,000 to 75,000		
Total............									110-162	55,000 to 81,000	56.24-112.24 ~~110-162~~	30,120 to 56,120

a/ U.S. Department of Agriculture, ESCS, and Hawaii Department of Agriculture, Statistics of Hawaiian Agriculture, 1979, June 1980.

b/ AGCHEMPRICE, 7-15-80.

c/ Consists of the 1977-79 average of 442 acres of taro ~~Taro~~ and 177 acres of daikon. ~~Daikon.~~

5. It was assumed that no new alternatives will become available in the near term, that the prices for alternative herbicides will not change, and the alternative will be available in sufficient quantities. It was also assumed that sufficient labor will be available for hand weeding at prevailing market prices.

6. An estimated 15 percent production loss is assumed with the alternative treatment program. This production loss includes (1) quality loss associated with the reduced efficiency in the selection process during cutting at harvest time due to weeds, (2) reduced product size due to weed competition, and (3) increased weediness in subsequent crops because of increased carryover weed seed on rhizomes ~~rhisomes.~~ Yield losses associated with the less-effective alternative weed-control program were estimated by agricultural scientists in the taro- ~~Taro-~~ and d~~D~~aikon-producing areas. These estimates were based on their experience and judgment about annual variations in production associated with different herbicides and hand weeding under general field conditions, and data from experimental research plots. However, research plot data may vary from actual field experience because they are obtained under specialized conditions.

7. Partial budgeting techniques were used to estimate the economic impact of a nitrogen ~~Tok~~ cancellation.

8. The treated acres are all in the taro and daikon ~~Taro and Daikon~~-growing areas of Hawaii.

Results

The 1977-79 average planted acres of Taro and Daikon in Hawaii was 619. Average farm value for Taro and Daikon in the same period was 13.9 cents per pound. Total production and value were 10,657,000 pounds and $1,484,000, respectively.

An estimated 500 acres of Taro and Daikon are treated annually with ~~Tok~~ nitrogen. About 4 pounds a.i. per acre, or a total of 2,000 a.i. pounds of nitrogen ~~Tok~~ are applied each year (table 1). At the current price of $7.94 per pound (a.i.), the cost of ~~Tok~~ nitrogen is $31.76 per acre. Application cost is $18 per acre. Total expenditures for ~~Tok~~ nitrogen use on Taro and Daikon is $24,880.

The alternative weed-control program includes one additional cultivation and two additional hand hoeings. Total cost of the alternative program is estimated to range from ~~be~~ $55,000 to $81,000, an increase in cost of $30,120 to $56,120, or about ~~$110~~ $50 to ~~$162~~ $112 per acre.

Use of the alternative ~~less effective~~ weed-control program is expected to result in a 15 percent yield decrease on the 500 acres currently treated. Average yields for 1977-79 were 17,216 pounds per acre. Therefore, at a value of 13.9 cents per pound of Taro and Daikon production, losses of ~~$179,450~~ $179,477 are estimated for the first year without ~~Tok~~ nitrogen. Additional losses would be expected as the weed population increases in subsequent years.

Total losses, including increased treatment costs and reduced production are estimated to be ~~$209,570~~ $209,597 to ~~$235,570~~ $235,597 the first year without ~~Tok~~ nitrogen. The data base is inadequate to determine if the 15 percent decrease in ~~T~~taro and ~~D~~daikon production in Hawaii would result in measurable price changes at the market or consumer level.

Summary

An estimated 500 acres of ~~T~~taro and ~~D~~daikon are treated with 2,000 pounds of ~~Tok~~ nitrogen for weed control annually. Total losses if the alternative weed-control program is used, including increased treatment costs and reduced production are estimated to be ~~$209,570~~ $209,597 to ~~$235,570~~ $235,597 the first year without ~~Tok~~ nitrogen. The 15 percent decrease in ~~T~~taro and ~~D~~daikon production in Hawaii is valued at ~~$179,450~~ $179,477 and increased weed-control costs are estimated to be $30,120 to $56,120.

PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON CALIFORNIA GREENHOUSE CARNATIONS

USE: Greenhouse carnations.

MAJOR PESTS CONTROLLED: Annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, sheperdspurse and spergularia.

ALTERNATIVES:

Major registered chemicals: Trifluralin is registered for use on carnations, but controls a different spectrum of weeds.

Non-chemical controls: Hand weeding.

Comparative performance: Annual yields would decrease by 8 percent from 717,800 to 660,400 blooms per acre with the use of four hand weedings.

Comparative cost: The cost difference per acre between hand weeding ($800-$1,200) and the nitrofen control program ($277-$377) would range from $523 to $883.

EXTENT OF USE: Currently about 16.1 percent of the California and 12.1 percent of the U.S. standard carnation acreage (69 acres) is treated with 276 pounds a.i. nitrofen.

ECONOMIC IMPACTS:

User: Increased production costs per acre will range from $523 to $833, which is a .8 to 1.3 percent increase in total production costs. The total production cost impact will range from $36,087 to $57,477.

Revenue losses for the 8 percent reduction in output would be about $5,116 per impacted acre.

Short term income losses per acre will range from $5,639 to $5,939. For the average sized grower (2.2 acres), the income loss will range from $12,406 to $13,066. The total industry income loss in the short term will range from $389,091 to $409,791.

Consumer: Short and long term consumer impacts are expected to be either negligible or nonexistent.

Macroeconomic: Macroeconomic impacts in the U.S. economy are expected to be either negligible or nonexistent. The comparative economic advantage of South American carnation producers may be enhanced with a further financial weakening of domestic producers.

SOCIAL/COMMUNITY IMPACTS: Social/community impacts are expected to be either negligible or nonexistent.

LIMITATIONS OF THE ANALYSIS: Additional labor for handweeding has been assumed readily available at existing wage rates and prices for different classes of chrysanthemums have been assumed constant. Limited biological data made it uncertain if growers without soil steam sterilization would shift into the production of other floricultural crops.

PRINCIPAL ANALYST AND DATE: H. W. Gaede
Economic Analysis Branch
Benefits and Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
January 1981

Preliminary Benefit Analysis of Nitrofen Use on Greenhouse Carnations in California

Current Use Analysis

Registrations of Nitrofen and Alternatives

Nitrofen formulated as either a 25EC or 50WP is registered as a weed control for annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, sheperdspurse and spergularia in carnations. One post-transplant spray application of 2 to 4 pounds a.i. mixed with 40 to 60 gallons of water is the labeled rate per acre application (EPA, 1980).

Trifluralin is EPA registered on carnations, but it controls a different spectrum of weeds. Specifically, malva, nightshade, nettle, sheperdspurse and spergularia are not included on the label (EPA, 1980).

Use of Nitrofen and Alternatives

Nitrofen usage of 276 pounds a.i. was applied to 69 acres (16.1 and 12.1 percent of the 1978/79 California and total U.S. acreage) of standard greenhouse carnations in California (Table 1). The primary target weeds include: nightshade, filagree, pigweed, and annual bluegrass. Nitrofen treatments are typically supplemented with one hand weeding for chickweed control (USDA/EPA/States, 1980).

Table 1. Use of Nitrofen and Alternatives on Greenhouse Carnations in California

Weed Control Program	Total Acres Treated	Total Pounds a.i.	Rate of Application Per Acre (lb. a.i.)	Number of Hand Weedings a/	Other Changes Affecting Production Costs	Percent Change in Bloom Output Per Acre
Nitrofen Program						
nitrofen (post-transplant)	69	276	4	1	—	—
Alternative Program						
hand weeding	69	—	—	4	b/	8.0c/

a/ It is estimated that from 26.7 to 40 hours of labor are required to hand weed one acre (USDA/EPA/States, 1980).
b/ Without nitrofen, a new producer may be forced to either invest in a steam treatment system or grow a different crop. However, the use of methyl bromide (used regardless of whether nitrofen is available or not) may provide sufficient weed control to prevent such adjustments (USDA/EPA/States, 1980).
c/ USDA/EPA/States, 1980.

Nitrofen may also provide the advantage of inexpensive weed control until a new carnation grower can more easily afford the investment costs of a preplant soil steam treatment system. However, it is possible that the scheduled use of methyl bromide as a preplant soil fumigant may also provide sufficient weed control to delay such an investment.

Without nitrofen, greenhouse carnation producers would use three additional hand weedings (a total of 80 to 120 hours of labor per acre) to permit the carnations to grow above the weeds. Quality losses are not anticipated, but annual yields would be expected to decline 8 percent from 717,800 to about 660,400 blooms per acre (USDA/EPA/States, 1980 and USDA, Floriculture Crops, 1980).

Economic Impact Analysis

Production Cost Changes

Based upon information presented in Table 1, the nitrofen weed control program for greenhouse carnations was estimated to cost between $277 and $377 per acre (Table 2). For the alternative weed control program of hand weeding, the per acre cost was estimated as ranging from $800 to $1200. Thus, the production cost impact of substituting hand weeding for nitrofen would range from $523 to $833 per acre if the price of hand weeding labor remained constant.

Information provided by the University of California at Berkeley indicates that total production costs for greenhouse carnations in

Table 2. Production Costs and Revenue Impacts Per Acre for a Nitrofen Suspension on Greenhouse Carnations in California

Weed Control Program	Pesticide Material Cost a/ (dollars)	Pesticide Application Cost b/ (dollars)	Hand Weeding Cost c/ (dollars)	Total Treatment Cost (dollars)	Total Revenues d/ (dollars)	Total Cost and Revenue Impact e/ (dollars)
Nitrofen Program						
nitrofen (post transplant)	31.76	45.00	200-300	277-377	63,956	
Alternative Program						
hand weeding	—	—	800-1,200	800-1,200	58,840	
difference				523-833	-5,116	-5,639 to -5,939

a/ For eight pounds of 50WP nitrofen (4 pounds AI) at $3.97 per pound.
b/ Nitrofen application requires 6 hours per acre at a wage rate of $7.50 per hour.
c/ See Table 1. Hand weeding labor is estimated to cost $7.50 per hour.
d/ Based upon an average 1978/79 yield of 717,800 standard carnation blooms per acre at a 1978/79 weighted average price of $.0891 per bloom (USDA, Floriculture Crops, 1980). Yield losses without nitrofen were estimated as 8 percent with hand weeding (Table 1).
e/ Assumes no change in labor costs or standard carnation market prices.

San Diego County is currently about $.09 per bloom (Eckhouse, 1980), which is about $64,600 per acre for the 1978/79 average output levels. Since greenhouse heating requirements are lower in this area, the total production cost estimate would probably be understated relative to other California producers. Given that the total production cost impact was estimated to range from $523 to $833 per acre, the percentage increase would be no greater than .8 to 1.3 percent.

Since 69 acres of carnations are subject to impact in California, the total production cost impact is estimated to range from $36,087 to $57,477.

Revenue Changes

The 69 acres subject to impact represent 16.1 percent of the 1978/79 standard carnation acres in California and 12.1 percent of the total U.S. Reduced California output was estimated as 3.96 million blooms which is approximately 1.3 and .9 percent of California and total U.S. production (USDA, Floriculture Crops, 1980). Therefore, any market price increases for standard carnations are expected to be negligible in the short term.

Under an assumption of no short term market price changes, the revenue loss would be approximately $5,116 per impacted acre when the 1978/79 weighted average price for California standard carnations is used in the calculations (Table 2). For the average sized carnation

grower (2.2 acres) that uses nitrofen on all acreage, the total revenue loss would be about $11,255. For the 69 impacted acres in California, the total revenue loss would be $353,004.

Potential Acreage Shifts

Nitrofen may provide an advantage to a new grower by delaying the investments costs of a preplant soil steam treatment system until the firm is financially more viable. Without the use of nitrofen or access to a steam treatment system, a new grower may be forced to produce a different floricultural crop. However, it is possible that methyl bromide soil fumigation, which would be used regardless of the market availability of nitrofen, may provide enough weed control to deter any acreage shifts.

It is uncertain if acreage will shift as a result of a regulatory action on nitrofen. For purposes of estimating short term impacts, no shift in acreage will be assumed. In the longer term, reductions in net farm income and a weakened economic advantage relative to foreign competition (i.e. South America) could force shifts of unknown magnitudes.

Net Farm Income Changes

Based upon the assumptions that hand weeding labor costs and market prices for standard carnations will not change, the short term reduction in net farm income per impacted acre is expected to range

from at least $5,639 to $5,939 when the 1978/79 California weighted average price is used for the calculations. For the average sized grower treating all acreage with nitrofen, the annual short term impact would range from at least $12,406 to $13,066. For all of the 69 affected acres in California, the total short term reduction in annual net farm income would range from at least $389,091 to $409,791.

In the longer term, these short term impacts could abate if biologically and cost competitive weed control strategies (either chemical, nonchemical, or both) were developed and made available to the impacted growers. However, without such developments, increased foreign competition could force financially weakened growers into alternative enterprises.

Consumer, Macroeconomic, Social/Community Impacts

Impacts in the form of consumer, macroeconomic or social/community are expected to be nonexistent or negligible in both the short and long term if nitrofen is not available to California greenhouse carnation producers.

Limitations of the Analysis

1. It has been assumed that the required labor for the additional hand weeding of greenhouse carnations is readily available at $7.50 per hour.

2. It is uncertain if the nonavailability of nitrofen will force new carnation growers without soil steam sterilization equipment into the production of other floricultural crops. Methyl bromide treatments were assumed to prevent such acreage shifts from occurring.

3. The California standard carnation industry currently appears to be declining in California because of increasing competition from South America and escalating production costs (Eckhouse, 1980). It is uncertain if a regulatory action on nitrofen will in itself force California growers into alternative enterprises.

4. Biological information on the alternative program and yield losses provided by the biologists were based on experience rather than field or trial data.

References

Eckhouse, K. EPA Cooperative Agreement with University of California at Berkeley. Personal communication. November 10, 1980.

U.S. Department of Agriculture. Floriculture Crops - Production Area and Sales, 1978 and 1979 Intentions for 1980, ESCS, Crop Reporting Board, Washington, D.C. April 1980.

U.S. Environmental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. July 1980.

U.S. Department of Agriculture. U.S. Environmental Protection Agency and State Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen. Washington, D.C. 1980.

PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON CALIFORNIA GREENHOUSE CHRYSANTHEMUMS

USE: Greenhouse chrysanthemums.

MAJOR PESTS CONTROLLED: Annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade nettle, pigweed, purslane, shepherdspurse and spergularia.

ALTERNATIVES:

Major registered chemicals: Trifluralin, CDAA, DCPA, EPTC and nitralin.

Non-chemical controls: Hand weeding.

Comparative performance: About 14 percent (85 to 93 percent of total output) of the higher qualit blooms will fall into smaller sized categories with the use of 4 to 5 hand weedings.

Comparative costs: The cost difference per acre between hand weeding ($800-$1,500) and the trofen contr program ($269-$369) would range from $531 to $1,131.

EXTENT OF USE: Currently about 10.9 percent of the California and 7.7 percent of the U.. standard chrysantheumum acreage (36 acres) is treated with 108 pounds a.i. nitrof .

ECONOMIC IMPACTS:

User: Increased production costs per acre will range from $531 to $1,131, which is a 1.1 to percent increase in total production cost. The total production cost im ct will rang from $19,116 to $40,716.

Revenue losses for 14 percent of the higher quality flowers falling into aller sized categories are about $.04 per bloom or from $1,244 to $1,364 per acre.

Short term income losses per acre will range from $1,755 to $2,495. The come loss f the average sized grower (1.95 acres) will range from $3,422 to $4,865 pe year. The total industry income loss in the short term will range from $63,180 to $),820.

Consumer: Short and long term consumer level impacts are expected to be either negl gible or nonexistant.

Macroeconomic: Macroeconomic impacts are expected to be either negligible or nonexistent

SOCIAL/COMMUNITY IMPACTS: Social/community impacts are expected to be either negligible or nonexist t.

LIMITATIONS OF THE ANALYSIS: Additional labor for hand weeding has been assumed readily available at e sting wage rates and prices for different classes of chrysantemums have been assumed onstant. Limited biological data made it uncertain if growers without soil stem st ilization would shift into the production of other floricultural crops.

PRINCIPAL ANALYST AND DATE:

H.W. Gaede
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
January 1981

Preliminary Benefit Analysis of Nitrofen Use on Greenhouse Chrysanthemums in California

Current Use Analysis

Registrations of Nitrofen and Alternatives

Nitrofen formulated as either a 25EC or 50WP is registered for weed control on annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nightshade, nettle, pigweed, purslane, sheperdspurse and spergularia in chrysanthemums. One pre- or postemergent spray application of 2 to 4 pounds a.i. mixed with 40 to 60 gallons of water is the labeled rate per acre application (EPA, 1980).

Other EPA registered herbicides for use on chrysanthemums include: trifluralin, CDAA, DCPA, EPTC, and nitralin.

Use of Nitrofen and Alternatives

Current use estimates of nitrofen on California standard greenhouse chrysanthemums is quite limited (see Table 1), since only 108 pounds a.i. were applied to 36 acres (USDA/EPA/States, 1980). The acreage subject to impact accounts for 10.9 and 7.7 percent of the 1978/79 California and total U.S. standard chrysanthemum acreage (USDA, Floriculture Crops, 1980). Nitrofen treatments are generally preceeded by one hand hoeing for cheeseweed, nightshades and pigweed control.

Nitrofen may also provide the advantage of inexpensive weed control until a new chrysanthemum grower can more easily afford the investment costs of a preplant soil steam treatment system. However, it is possible that the scheduled use of methyl bromide as a preplant soil fumigant may also provide sufficient weed control to delay such an investment

Without nitrofen, greenhouse chrysanthemum producers would use 3-4 additional hand weedings to enable the chrysanthemums to grow above the weeds. Quantity losses are not expected, but 14 percent of the higher quality chrysanthemums are anticipated to fall into lower quality categories (USDA/EPA/States, 1980).

Economic Impact Analysis

Production Cost Changes

Based upon information presented in Table 1, the nitrofen weed control program for standard greenhouse chrysanthemums was estimated to cost between $269 and $369 per acre (Table 2). For the alternative weed control program of 4-5 hand weedings, the per acre cost was estimated as ranging from $800 to $1,500. Thus, the production cost impact of substituting hand weeding for nitrofen would range from $531 to $1,131 per acre if the price of hand weeding labor remained constant.

Table 1. Use of Nitrofen and Alternatives on Greenhouse Chrysanthemums in California

Weed Control Program	Total Acres Treated	Total Pounds a.i.	Rate of Application Per Acre (lb. a.i.)	Number of Hand Weedings a/	Percent Change in Bloom Output Per Acre
Nitrofen Program					
nitrofen (postemergence)	36	108	3	1	--
Alternative Program					
hand weeding		--	--	4-5	b/

a/ It is estimated that from 26.7 to 40 hours of labor are required to hand weed one acre (USDA/EPA/States, 1980).

b/ The quantity of produced chrysanthemums would not change, but 14 percent of the higher quality flowers (about 85 to 93 percent of the total crop are classed as either large or very large blooms) would fall into lower quality classes (USDA/EPA/States, 1980).

Information provided by the University of California at Berkeley indicates that total production costs are approximately 95 percent of total revenues (Eckhouse, 1980), which is about $47,250 per acre for the 1978/79 average revenues. Given that the total production cost impact was estimated to range from $531 to $1,131 per acre, the increase would range from 1.1 to 2.4 percent.

Since 36 acres of California chrysanthemums are subject to impact, the total production cost impact is estimated to range from $19,116 to $40,716.

Revenue Changes

The 36 acres subject to impact if nitrofen is cancelled/suspended account for 10.9 and 7.7 percent of the standard chrysanthemum acreage in California and the U.S., respectively (USDA, Floriculture Crops, 1980). Changes in the quantity of production are not expected, but 14 percent of the higher quality chrysanthemums (85 to 93 percent of total output is estimated to be large or very large blooms) are expected to fall into smaller sized categories (USDA/EPA/States, 1980)1/. Under the assumptions that prices will not change for different size classes of chrysanthemums and that the current price spread between larger and smaller size classes is approximately $ .04 per bloom (Eckhouse, 1980), revenue losses would range from approximately $1,244 to $1,364 per acre (Table 2).

1/ Industry wide market grade standards currently do not exist for California chrysanthemums (Eckhouse, 1980).

Table 2. Production Costs and Revenue Impacts Per Acre of a Nitrofen Suspension on Greenhouse Chrysanthemums in California

Weed Control Program	Pesticide Material Cost a/ (dollars)	Pesticide Application Cost b/ (dollars)	Hand Weeding Cost (dollars)	Total Treatment Cost (dollars)	Total Revenues (dollars) c/	Total Cost and Revenue Impact (dollars) d/
Nitrofen Program						
nitrofen (postemergence)	23.82	45.00	200–300	269–369	51,849	
Alternative Program						
hand weeding	—	—	800–1,500	800–1,500	50,605–50,485	
difference				531–1,131	1,244–1,364	1,755–2,495

a/ For six pounds of 50WP nitrofen (3 pounds a.i.) at $3.97 per pound.
b/ Nitrofen application requires 6 hours per acre at a wage rate of $7.50 per hour.
c/ Based upon an average 1978/79 yield of 261,600 standard chrysanthemum blooms per acre at 1978/79 weighted average price of $.1982 per bloom (USDA, Floriculture Crops, 1980). Approximately 14 percent of 222,4000 to 243,300 blooms would fall into a lower quality class that is valued at $.04 less per bloom.
d/ Assumes no change in labor costs or standard chrysanthemum market prices.

For the average sized California chrysanthemum grower (1.95 acres) that uses nitrofen on all acres, the total revenue loss would range from about $2,426 to $2,660. The 36 acres impacted in California would have an estimated total revenue loss ranging from $44,784 to $49,104.

Net Farm Income Changes

Based upon the assumptions that hand weeding labor costs and market prices for different classes of California standard chrysanthemums will not change, the short term reduction in net farm income per impacted acre is expected to range from $1,755 to $2,495. For the average sized grower treating all acreage with nitrofen, the short term impact would range from $3,422 to $4,865. For all of the 36 affected acres in California, the short term reduction in net farm income would range from $63,180 to $89,820.

In the longer term, these short term impacts could abate if biologically and cost competitive weed control strategies (either chemical, nonchemical, or both) were developed and made available to the impacted growers.

Consumer, Macroeconomic, Social/Community Impacts

Impacts in the form of consumer, macroeconomic or social/community are expected to be nonexistent or negligible in both the short and long term if nitrofen is not available to California greenhouse chrysanthemum producers.

Limitations of the Analysis

1. It has been assumed that the required labor for the additional hand weeding of greenhouse chrysanthemums is readily available at current wage rates.

2. It is uncertain if the nonavailability of nitrofen will force chrysanthemum growers without soil steam sterilization equipment into the production of other floricultural crops. Methyl bromide treatments were assumed to prevent such acreage shifts from occurring.

3. It has been assumed that prices for different classes of California chrysanthemums will remain unchanged. A $.04 per bloom quality loss is expected for 14 percent of the large and very large blooms.

References

Eckhouse, K. EPA Cooperative Agreement with University of California at Berkeley. Personal communication. November 21, 1980.

U.S. Department of Agriculture. Floriculture Crops - Production Area and Sales, 1978 and 1979 Intentions for 1980. ESCS, Crop Reporting Board. Washington, D.C. April 1980.

U.S. Department of Agriculture, U.S. Environmental Protection Agency and State Assessment Team for Nitrofen. Draft Biological Assessment for Nitrofen. Washington, D.C. 1980.

U.S. Environmental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD. Washington, D.C. 1980.

Preliminary Benefit Analysis of Nitrofen Use on Ornamental Ground Covers in California

Current Use Analysis

Nitrofen formulated as a 50 WP is registered as a selective herbicide to control various broad leafed weeds in fields in which ornamental ground covers are being established. One or two applictions of four pounds a.i. each are applied each are applied per acre.

Trifluralin, oryzalin, napropamide and DCPA are also registered for use on ornamental ground covers. However, they do not provide control of the broad leaf weeds controlled with nitrofen. The alternative control program would be to increase hand hoeing to control those weed species not controlled due to the loss of nitrofen (USDA/USEPA/STATES, 1980).

Use of Nitrofen and Alternatives

The USDA/EPA/State Nitrofen Assessment Team estimated that 6,290 acres of ornamental ground covers are treated with 26,360 pounds of nitrofen on an annual basis. The weed control programs with nitrofen consist of nitrofen and oryzalin or napropamide and an additional application of nitrofen on about 5 percent of the acres. The seeded is also mechanically cultivated prior to planting and hand weeded (hoeing or pulling) one to three times over the establishment period. The weed control program consists of oryzalin or napropamide, one mechanical cultivation prior to planting plus two to four hand weedings (USDA/USEPA/S

Economic Impact Analysis

It is expected that the loss of nitrofen would result in ground cover establishment cost increases of $5.2 million (Table 2). This would consist of increased hand weeding costs of $5.4 million and decreased herbicide costs

of $0.2 million.

Ornamental ground covers are perennials which are established once and have an indefinite life span if maintained. The increased establishment cost would not occur every year. However, if past ground cover establishment rates continue, the increased establishment costs would occur on areas where ornamental ground covers are being established.

Market and Consumer Impacts

Ornamental ground covers are treated with nitrofen near new construction on public and private lands. Given the magnitude of the expected impacts which would occur only once on any piece of land, it is not expected that the loss of nitrofen would have any significant market impacts. However, these cost increases would increase the cost of new construction where ornamental ground covers are established.

Limitations

1. The information on the extent of use and on increased establishment costs was based on the expertise of the Assessment Team rather than on experimental or field data.
2. It was assumed that increased hand labor would be available without increased unit costs.

Table 1. Use of Nitrofen on Ornamental Ground Covers in California.[a]

Weed control program	Acres treated with nitrofen	Pounds a.i. applied	Application rate per acre	Number of mechanical cultivations	Number of hand hoeings	Othe char
	Pounds a.i.					
With nitrofen						
Program A				1	1-3	NA
Nitrofen	4,403	17,612	4			
Oryzalin	4,403	17,612	4			
Nitrofen	210	840	4			
Program B						
Nitrofen	1,887	7,548	4	1	1-3	NA
Napropamide	1,887	7,548	4			
Nitrofen	90	360	4			
Without Nitrofen						
Program A				1	2-4	No
Oryzalin	4,403	17,612	4			
Program B				1	2-4	No
Napropamide	1,887	7,548	4			

a/ Provided by USDA/State/EPA Nitrofen Assessment Team.

Table 2. Increase in ground cover establishment costs without nitrofen.

Weed control program	Acres treated a/	Herbicide costs b/	Herbicide application costs c/	Increased hand hoeing costs d/	Increased establishmer costs
	$1,000				
Program A					
With Nitrofen					
Nitrofen	4,403	139.8	35.2		
Oryzalin	4,403	164.3			
Nitrofen	210	6.7	1.7		
Sub-total		310.8	36.9		
Without Nitrofen					
Oryzalin	4,403	164.3	35.2	3,790.9	
Difference		(146.5)	(1.7)	3,790.9	3,642.7
Program B					
With Nitrofen					
Nitrofen	1,887	59.9	15.1		
Napropamide	1,887	82.4			
Nitrofen	90	2.9	0.7		
Sub-total		145.2	15.8		
Without Nitrofen					
Napropamide	1,887	82.4	15.1	1,624.7	1,561.2
Difference		(62.8)	(0.7)	1,624.7	
Total					5,203.9

a/ Table 1.

b/ Based on costs of $7.94 per pounds a.i. of Nitrofen; $9.33 per pound a.i. of Oryza and $10.92 per pound a.i. of Napropamide. Herbicide prices from as Chem. Price, El Paso TX, 1980. Application rates from Table 1.

c/ Herbicide application cost of $8.00 per acre per application. Note, Nitrofen and Oryzalin are applied together as are Nitrofen and Napropamide.

d/ Based on 82 hours of additional hand hoeing per acre at $10.50 per hour. Data supplied by Nitrofen Assessment Team.

Preliminary Benefit Analysis of Nitrofen Use on Field Grown Roses in California

Current Use Analysis

Nitrofen formulated as a 50 WP is registered as a selective herbicide to control various broad leafed weeds in rose fields. 1/ Two applications of two pounds a.i. each are mixed with 40 to 60 gallons of water per acre.

SP Trifluralin, oryzalin and oxadiazon are registered for use on field grown roses. However, they do not provide control of the broad leaf weeds controlled with nitrofen. The alternative control program would be to increase the hand hoeing to control those weed species not controlled due to the loss of nitrofen (USDA/USEPA/STATES, 1980).

Use of Nitrofen and Alternatives

The USDA/USEPA/State Nitrofen Assessment Team estimated that 164 acres of field grown roses are treated with a total of 656 pounds of nitrofen on an annual basis. The weed control program with nitrofen consists of trifluralin incorporated preplant, preplant mechanical culitvation, 2 nitrofen applications, a postplant pre-emergence treatment with oxadiazona, and 2 hand hoeings each taking about 13 person hours. Without nitrofen the program would include an additional hand hoeing (USDA/USEPA/S

Economic Impact Analysis

It is expected that the loss of nitrofen would result in production costs increases of $8,820 or $53.78 per acre for those acres treated (Table 2). There are no expected production losses. The magnitude of

1/ Field roses are propagated for sale as rooted or bareroot plants throughout the U.S.

these impacts suggests that there would be no shifts out of field rose production.

Consumer and Market Impacts

The expected prodution impacts are of minor magnitude and would not have any significant consumer or other non-producer impacts.

Limitations of Analysis

1. Usage of nitrofen was estimated by the Assessment Team. However, even if all rose acres in California were treated, the loss of nitrofen would have a small impact unless significant yield impacts were involved. Given the nautre of the field grown rose as a strong plant, significant yield losses are highly unlikely.

Table 1. Weed control programs for field grown roses in California a/

Weed control program	Acres treated	Application rate per acre lb. a.i.	Total lbs. a.i. applied	Number of mechanical cultivations	Number of hand hoeings
With					
Nitrofen	164				
Trifluralin		2	328		
Nitrofen		4	656		
Cultivations				1	2
Oxidiazona		4	656		
Without					
Nitrofen	164				
Trifluralin		2	328		
Cultivations				1	3
Oxidiazona		4	656		

a/ USDA/USEPA/State Nitrofen Assessment Team, 1980.

Table 2. Cost of production increaes due to loss of nitrofen on field grown roses in California. a/

Weed control program	Acres treated	Herbicide costs b/	Herbicide application costs	Mechanical cultivation costs	Hand cultivation costs	Production total	% Cost increase per acre
		Dollars					
With Nitrofen	164	31,786	6,806	1,312	31,980		
Without Nitrofen	164	27,240	4,182	1,312	47,970		
Cost increase (decrease)		(4,546)	(2,624)	0	15,990	8,820	53.78

a/ Quantities applied and number of cultivations from Table 1. Costs supplied by Gordon Rowe, Extension Economist, University of California, Berkley, 1980.

b/ Based on 2 pounds a.i. trifluralin per acre at $8.05 per pounds a.i. oxidiazon per acre at $37.80 per pound; and 4 pounds a.i. nitrofen per acre at $6.93 per pound. Chemical prices from Ag. Chem Price, El Paso, Texas, 1980.

c/ Pesticide application costs $8.00 per acre per application for nitrofen and oxidiazon and $17.50 per acre for trifluralin.

d/ Mechanical cultivation cost of $8.00 per acre.

e/ Based on 13 person hours per acre per hoeing at $7.50 per hour.

SUMMARY OF BENEFIT ANALYSIS OF NITROFEN USE ON ROSES

A. USE: Nitrofen use on roses (primarily greenhouse).

B. MAJOR PESTS CONTROLLED: Weeds controlled include: annual bluegrass, crabgrass, goosefoot, lambsquarter, malva, nettle, nightshade, pigweed, purslane, sherperdspurse and spergularia.

C. ALTERNATIVES:

Major registered herbicides: Alternative active ingredients include: cacodylic acid, DCPA, diphenamid, EPTC, oxadiazon simazine and trifluralin.

Non-chemical weed control methods: Soil steam treatment and hand weeding.

Efficacy/performance: Alternative weed control program consisting of additional hand weeding followed by oxadiazon preemergence treatment will not affect cut rose quality.

Comparative Costs: Comparative Annual Treatment Costs Per Acre of Nitrofen and Alternative Control Programs on Roses in California

Weed Control Program	Product Treatment Cost ($)	Pesticide Application Cost ($)	Additional Hand Weeding Cost ($)	Total Annual Program Treatment Cost ($)
trifluralin + nitrofen	71.54	135.00	—	206.54
oxadiazon + nitrofen	130.20.	135.00	—	265.20
add'l weeding + oxadiazon	74.76	45.00	250.00	396.76

D. EXTENT OF USE: Approximately 25 acres of California roses were treated with nitrofen in 1977, 1978 and in 1979. Nitrofen-treated acreage represents 4.6% and 5.3% of total rose acreage for 1978 and 1979. About 200 lbs. nitrofen a.i. are used each year on roses.

E. ECONOMIC IMPACT:

User: Growers would experience a $104.56 to $163.22 per acre annual cost increase by using the alternative weed control program. Total annual treatment cost impact per producer would be approximately $354 to $553. The percentage increase in total annual production costs would be less than .5%. Total short term production cost increase for the rose industry would equal about $2,614-$4,081.

Consumer/market: None expected.

Macroeconomic: None expected.

F. SOCIAL/COMMUNITY IMPACTS: None expected.

G. LIMITATIONS OF ANALYSIS: Limited usage data were available for the selected alternative herbicide, oxadiazon; no test data were availale on comparative efficacy between nitrofen and alternative controls; it was assumed that labor and other factors of production are readily available at existing prices.

H. PRINCIPAL ANALYST AND DATE:

Katherine Devine
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
Washington, D.C.
December, 1980

PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON ROSES

Current Use Analysis

EPA Registrations of Nitrofen and Alternatives

The herbicide, nitrofen, formulated as a 25% emulsifiable concentrate, is EPA registered to control the following weeds in roses: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nettle, nightshade, pigweed, purslane, sheperdspurse and spergularia (EPA, 1980).

The alternative active ingredients registered with the EPA include: cacodylic acid, DCPA, diphenamid, EPTC, oxadiazon, simazine, and trifluralin (EPA, 1980; USDA/EPA/States, 1980). Non-chemical methods of weed control in roses include steam treatment of the soil[1/] and hand weeding (USDA/EPA/States, 1980).

1/ Not applicable after transplanting (USDA/EPA/States, 1980).

Use of Nitrofen and Alternatives

Nitrofen is a postemergence pesticide applied to roses[1/] in sequence with other herbicides. Approximately 25 acres of California roses were treated in 1978 and 1979. Since there were 541 and 471 acres of roses planted in 1978 and 1979, respectively (USDA/EPA/States, 1980), the nitrofen-treated acreage represents 4.6% and 5.3% of total rose acres for 1978 and 1979[2/].

Nitrofen is applied at a rate of 4 lbs. a.i./acre per application; a total of two applications are made annually (USDA/EPA/States, 1980). Therefore, about 200 lbs. nitrofen a.i. are used each year on roses.

Most of the registered alternatives control only some of the weeds listed above and trifluralin does not control oxalis (USDA/EPA/ States, 1980). However, oxadiazon, newly registered for roses, is considered

---

1/ Although nitrofen is used primarily on greenhouse roses, there is also usage on field roses (Elmore, 1980). The extent of field usage is considered relatively minor.

2/ It is assumed that the reported planted and treated acreage refer to actual acreage and do not include areas, such as walkways, that would not receive pesticide treatment. This assumption is partially based on the fact that the total number of square feet of rose production area reported for 1978 and 1979 equals about 633.2 and 668.8 acres, respectively. This acreage is a "gross" area and, therefore, includes walkways and aisles (USDA, 1980).

partially effective as a preemergence treatment (USDA/EPA/States, 1980). There were no specific data available on oxadiazon usage on roses, but the California Department of Food and Agriculture reports that .02 lbs. oxadiazon a.i. were used on .06 acres of "flowers" in 1979. This number, however, reflects usage by licensed pest control operators and, therefore, is not all encompassing.

Comparative efficacy/quality/yield data between nitrofen and any of the alternative herbicides listed were not available. However, using an alternative weed control program that consists of additional hand weeding followed by oxadiazon preemergence treatment will not affect the quality of cut roses. Also, nitrofen is not used for yield increases but rather to keep the crop clean and ensure worker comfort from weed irritation (USDA/EPA/States, 1980). Nitrofen usage also may enable a new rose producer to delay investment in a soil steam treatment system.

ECONOMIC IMPACT ANALYSIS

User Impacts

Standard weed control treatment of roses consists of a trifluralin or oxadiazon application followed by hand weeding, if oxalis is not present. If oxalis is present, a trifluralin or oxadiazon application is followed by two nitrofen applications. If nitrofen were unavailable a grower would be likely to use the weed control program consisting of hand weeding and an oxadiazon preemergence treatment (USDA/EPA/States,

1980). Total treatment costs for the three weed control programs on a per acre basis are as follows: trifluralin + nitrofen = $206.54; oxadiazon + nitrofen = $265.20; and hand weeding + oxadiazon = $369.76 (Table 1).

The relatively high cost of additional hand weeding ($200-$300/acre) will cause the hand weeding + oxadiazon control program to be more costly than either of the programs using nitrofen. Therefore, if nitrofen becomes unavailable, growers will experience a $104.56 to $163.22 per acre annual cost increase. On the average, California growers commit about 4.37 acres to rose production (USDA, 1980)1/. It is estimated that greenhouse areas (e.g. walkways) not receiving pesticidal treatment comprise 15%-30% of the total production area. This estimate is derived from reported rose acreage (USDA/EPA/States, 1980) and gross production area (USDA, 1980). Based on the midpoint of this estimate, the treatment cost impact per producer would be approximately $354 to $553 for about 3.39 acres of growing area.

It is estimated that the total annual rose production cost in northern California is $2.75-$3.00 per square foot (Hasek, 1980) or $119,790-$130,680 per acre. The percentage increase in total annual production costs due to the unavailability of nitrofen would be less than .2% for northern California growers. Total rose production costs for warmer areas of California are unknown. Although it is possible that cooling costs may be incurred by growers in some of the warmer

---

1/ Based on reported 1978 and 1979 rose production area and number of producers; data for 1977 was not available.

Table 1. Comparative Annual Treatment Costs Per Acre of Nitrofen and Alternative Control Programs on Roses in California

Weed Control Program	Product Cost Per Lb. A.I. ($)	Product Application Rate (Lb. A.I.)	Product Treatment Cost ($)	Pesticide Application Cost a/ ($)	Additional Hand Weeding Cost b/ ($)	Total Annual Program Treatment Cost ($)	Difference in Total Annual Treatment Costs Between Nitrofen and Alternative ($)
Trifluralin + nitrofen c/	8.05 + 6.93	2 + 4 + 4	71.54	135.00	–	206.54	–
Oxadiazon + nitrofen c/	18.69 + 6.93	4 + 4 + 4	130.20	135.00	–	265.20	–
Additional hand weeding + oxadiazon d/	18.69	4	74.76	45.00	250.00	369.76	104.56 to 163.22

a/ Based on the assumption that prices for labor and other factors of production remain constant. For each herbicide application, cost consists of six hours of labor at a wage rate of $7.50/hr. (USDA/EPA/States, 1980).
b/ Based on a midpoint of $200.00-$300.00 per acre (USDA/EPA/States, 1980).
c/ One application of trifluralin or oxadiazon is followed by two applications of nitrofen (USDA/EPA/States, 1980).
d/ One application of oxadiazon is followed by one additional hand weeding (USDA/EPA/States, 1980).

Source: USDA/EPA/States, 1980.

areas, it is assumed that northern California total production costs are the highest, with heating costs equal to approximately $.71 per square foot (Hasek, 1980) or about 25% of total costs. Based on this information, it is estimated that California growers in regions other than northern areas would experience an increase in total annual production costs of less than .5%.

Since about 25 acres of roses are treated with nitrofen each year (USDA/EPA/States, 1980), the total short term production cost increase for the rose industry would equal about $2,614-$4,081.

Consumer/Market/Macroeconomic/Social/Community Impacts

No consumer, market, macroeconomic, or social/community impacts are expected if nitrofen is not available for use.

LIMITATIONS OF ANALYSIS

1. There were limited usage data available for the selected alternative herbicide, oxadiazon.

2. There were no test data available on the comparative efficacy between nitrofen and alternative controls.

3. It was assumed that labor and other factors of production are readily available at existing prices.

REFERENCES

California. 1979. California Department of Food and Agriculture. Annual Pesticide Use Report. Sacramento.

Elmore, Clyde. 1980. Weed Science Extension. University of California. Davis, California. Personal communication. December 10.

Hasek, Ray. 1980. Environmental Horticulture Extension. University of California. Davis, California. Personal communication. December 17.

U.S. Department of Agriculture. 1980. Floriculture Crops - Production Area and Sales: 1978 and 1979, Intentions for 1980. Economics, Statistics and Cooperatives Service. Crop Reporting Board. Washington, D.C. April.

U.S. Department of Agriculture/U.S. Environmental Protection Agency/States Assessment Team for Nitrofen. 1980. Draft Biological Assessment of Nitrofen. Washington, D.C.

U.S. Environmental Protection Agency. 1980. Benefit Analysis of Nitrofen. Office of Pesticide Programs. Benefits and Field Studies Division. Washington, D.C. July.

Preliminary Benefit Analysis of Nitrofen Use on Stock in California

Current Use Analysis

Nitrofen, formulated as a 25 EC and a 50 WP is registered as a herbicide for cheeseweed, nightshade, pigweed and neetle in stock fields. 1/ One post-plant application of 4 pounds a.i. mixed with 40-60 gallons of water is applied per acre.

Trifluralin is the only other herbicide registered for use on stock. It can not be considered an alternative to nitrofen. Nitrofen is current by applied to control weeds not controlled by trifuralin. The alternative control to nitrofen would be to increase mechanical cultivation and hand weeding (USDA/USEPA/STATES, 1980).

Use of Nitrofen and Alterntives

The Assessment Team estimated that 280 acres of stock are treated with 1,120 pounds of nitrofen. The weed control program with nitrofen consists of trifluralin incorporated pre-plant, nitrofen early post emergence, 1 to 2 mechanical cultivations and 1 hand hoeing to control escape weeds. The weed control program without nitrofen consists of replacing nitrofen with 1 to 2 additional hand hoeing each taking 16 to 20 person hours (USDA/USEPA/STATES, 1980)

Economic Impact Analysis

It is expected that the loss of nitrofen would result in production cost increases of $22,467 or $80.24 per acre for those acres treated (TABLE 2). There would be

1/ Stock is a cool weather floral crop grown commercially only in Arizona and California.

increased labor charges of $33,600 and decreased herbicide and herbicide application costs of $11,133. The assessment team projected yield losses of 10 percent on those acres treated. This would result in $110,880 value of lost production to those producers using nitrofen. The total reduction in revenues to those producers using nitrofen would be $133,347; $22,467 increased production costs and $110,880 value of lost production.

Stock is a speciality floral crop and one expects that other cut flowers could be used as close substitute. Therefore, one would expect that stock producers could not pass on the cost of production increases. In addition, it is expected that the reduced production would not result in significant price adjustments. Production budgets are not available for stock. Without budgets one cannot project acreage shifts due to revenue losses and prodution cost increases.

Consumer Impacts

Data does not exist to predict consumer impacts. However, given the small quantity of stock produced and the substitutability of other flowers it is reasonable to project negligible consumer impacts.

Limitations of Analysis

1. This study has weak biological foundations. The Assessment Team estimated nitrofen use, the alternative control program and yield losses based on their experience rather than on controlled experiments.

2. The lack of stock production budgets prevented development of viable estimates of impacts to individual producers.

3. The loss of nitrofen for use on other cut flower sites could have a componing effect since carnations, chrysanthemums and roses with also be impacted. These flowers are substitutes for stock.

4. In this analysis it was assumed that hand labor would be available to weed stock at no change in price. However, nitrofen has replaced a large portion of the hand labor for California agriculture and it is not known if hand labor would again be available without significant price increases.

Table 1. Weed control programs for stock with and without nitrofen. a/

Weed control program	Acres treated	Application rate per acre	Total pounds applied	Number of mechanical cultivations	Number of hand hoeings b/	Yield reductic per acre
	Acres	Lbs. a.i.	Lbs. a.i.			Percent
With Nitrofen						
Trifluralin	700	1	700			
Nitrofen	280	4	1,120			
Cultivations				1-2	1	0
Without Nitrofen						
Trifluralin	700	1	700			
Cultivations				1-2	2-3	10

a/ Estimated by the uSDA/USEPA and State Nitrofen Assessment Team, 1980.

b/ There would be one hand hoeing with nitrofen taking 16-20 person hours per acre. Hand hoeings would increase to 2-3 each taking 16-20 person hours with nitrofen not available.

Table 2. Grower net revenue decreases from a loss of nitrofen on stock. a/

Weed control program	Acres treated	Herbicide costs	Herbicide application costs d/	Mechanical cultivation costs e/	Hand hoeing costs e/	Total production cost increases	Value produ losse
	Dollars						
With Nitrofen b/	280	11,250	7,000	3,360	33,600-67,200		
Without Nitrofen c/	280	2,358	4,760	3,360	67,200-100,800		110,
Difference (decrease)		(8,893	(2,240)	0	33,600	22,467	

a/ Table 1.

b/ 4 pounds nitrofen per acres at $7.94 a pound and 1 pound trifluralin per acre at $8.42 a pound for a total of $40.18 per acre. Prices obtained from Ag. Chem. price, El Paso, TX, 1980.

c/ 1 pound trifluralin per acre at $8.42 a pound.

d/ Application cost of $8.00 per acre for nitrofen and $17.00 per for trifluralin. Provided by Gordon Rowe, Extension Economist, University of California, Berkley.

e/ Mechanical cultivation costs of $12.00 per acre; hand hoeing cost of $120.00 per acre per hoeing (16 person hours at $7.50 per acre). From Gordon Rowe, Extension Economist, University of California, Berkley.

f/ Based on 10 percent yield loss on treated acres and crop value estimated at $3,960 per acre. Crop value estimated by USDA/USEPA/State Nitrofen Assessment Team.

SUMMARY OF BENEFIT ANALYSIS OF NITROFEN USE ON NON-CROPLAND

USE: Nitrofen use on fencerows, rights-of-way, storage yards and fallow land that is followed by labeled crops (carrots, celery, cole crops, garlic, horseradish, onions, Oriental vegetables, parsley and sugarbeets).

MAJOR PESTS CONTROLLED: Weeds controlled include: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nettle, nightshade, pigweed, purslane, sheperdspurse and spergularia.

ALTERNATIVES:

Major registered herbicides: A partial list of alternative active ingredients includes: atrazine; dicamba + 2,4-D; diuron; and isopropylamine salt of glyphosate.

Comparative costs: Comparative Acre Treatment Costs of Nitrofen and Selected Alternatives

Herbicide (Formulation)	Total Per Acre Treatment Cost ($)
nitrofen (25EC)	46.12
nitrofen (50WP)	51.67
atrazine (80WP)	24.89
dicamba + 2,4-D (L)	14.47
diuron (80W)	53.00
glyphosate (L)	42.60

ECONOMIC IMPACT:

User: The nitrofen formulation primarily used is 25EC. Based on this fact, total treatment cost changes due to usage of selected alternatives will range from $6.88 more to $31.65 less per acre. Therefore, usage of alternative herbicides may result in decreased or increased annual short and long run user expenditures.

Consumer/market: None expected.

Macroeconomic: None expected.

SOCIAL/COMMUNITY IMPACTS: None expected.

LIMITATIONS OF ANALYSIS: No complete usage data were available for nitrofen and selected alternatives; no test data were available on comparative efficacy of nitrofen and alternative herbicides; a complete listing of weeds controlled by all alternatives to nitrofen was unavailable; it is unknown whether any additional mowings and/or hand cuttings would be necessary with usage of alternatives; it was assumed that the cost of pesticide application equipment and labor for non-restricted herbicides will equal $8.00/acre while restricted use pesticide application costs will be 2-3% higher.

PRINCIPAL ANALYST AND DATE:

Katherine Devine
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
Washington, D.C.
December, 1980

PRELIMINARY BENEFIT ANALYSIS OF NITROFEN USE ON NON-CROPLAND

Current Use Analysis

EPA Registrations of Nitrofen and Alternatives

The herbicide, nitrofen, formulated as either a 25% emulsifiable concentrate or a 50% wettable powder, is Federally registered for use on fencerows, rights-of-way, storage yards and fallow land that is followed by labeled crops[1/] to control several weeds including: annual bluegrass, crabgrass, goosefoot, lambsquarters, malva, nettle, nightshade, pigweed, purslane, sheperdspurse and spergularia (EPA, 1980).

The alternative active ingredients registered with the EPA for control of some of the weeds listed above include: atrazine; dicamba + 2,4-D; diuron; and isopropylamine salt of glyphosate[2/] (USDA/EPA/States, 1980). It should be noted, however, that this list is not all inclusive, a complete listing of weeds controlled by each alternative is unavailable, and it is not possible to make control comparisons between nitrofen and each of the alternatives.

1/ Agricultural crops covered by the nitrofen label include: carrots, celery, cole crops (broccoli, Brussels sprouts, cabbage, cauliflower), garlic, horseradish, onions (dry bulb), Oriental vegetables (Chinese cabbage, mustard greens, kales, Chinese parsley, daikon, dasheen, gobo, yam bean, dryland taro), parsley and sugarbeets.

2/ Hereafter referred to as glyphosate.

Although these specific alternative herbicides listed may control many of the same weeds as nitrofen, the herbicides are ineffective against the following: burning nettle, cheeseweed, ground cherry, nightshade, oxalis and silversheath knotweed (USDA/EPA/States, 1980). It is not known to what degree these weeds present a problem and whether herbicides, other than those listed above, would provide control comparable to nitrofen.

Use of Nitrofen and Alternatives

Although registered for both preemergence and postemergence application to non-cropland areas (EPA, 1980), nitrofen usage consists of postemergence application, primarily in California, at a rate of 5-6 lbs. a.i./acre; treatment consists of one application (USDA/EPA/States, 1980). Data on the total number of non-cropland acres existing in California and the United States, as well as the number of nitrofen-treated acres and the total nitrofen usage, were unavailable. However, the California Department of Food and Agriculture reported use on "non-agricultural areas" ranging from about 15 lbs. a.i. on 5 acres to 410 lbs. a.i. on 235 acres during 1977-79. Also, in 1979, 5 lbs. nitrofen a.i. were used on rights-of-way (California; 1979, 1978 and 1977). Although these numbers reflect usage by licensed pest control operators and are not all encompassing[1/], the figures do indicate that total nitrofen usage on non-cropland sites is negligible.

1/ California Department of Food and Agriculture pesticide usage figures reflect 85% to 100% of licensed applicator usage in 1977-1979 and listed sites, such as "agencies, other", could possibly account for some additional use.

Use information concerning the acres treated with nitrofen in sequence with other herbicides, as well as the number of applications and lbs. a.i./acre, is unknown.

California alternative herbicide usage estimates are also limited. The California Department of Food and Agriculture reports that licensed pest control operators' annual usage of atrazine was less than 7,000 lbs. a.i. on less than 2,000 acres of "non-agricultural areas" and "fallow farmland"; about 370,000 lbs. a.i. were used for rights-of-way in 1979. Diuron usage by licensed operators increased between 1977-79 from approximately 2,700 lbs. a.i. on 450 acres of "non-agricultural areas" to about 143,000 lbs. a.i. on 1,700 acres of non-agricultural land and unspecified rights-of-way acreage. Licensed operator usage of glyphosate also increased between 1977-1979. About 9,200 non-agricultural acres were treated with 3,200 lbs. glyphosate a.i. in 1977; about 5,000 acres of non-agricultural land and an unspecified amount of rights-of-way of acreage were treated with 152,000 lbs. a.i. in 1979. There were no California usage estimates available for the combination product of dicamba and 2,4-D (California; 1979, 1978 and 1977).

User Impacts

As previously indicated, nitrofen usage data on non-cropland are extremely limited. Other data limitations include performance comparisons between nitrofen and alternatives and whether any additional mowings and/or hand cuttings would be necessary with the alternatives. Since the total number of non-cropland acres treated with nitrofen is unknown, the cost impact resulting from unavailability of this herbicide can only be assessed on a per acre basis.

The assessment of total per acre treatment costs of nitrofen and selected alternatives is based on the assumption that the cost of pesticide application equipment and labor for non-restricted use pesticides will equal $8.00/acre (USDA/EPA/States, 1980). The fact that dicamba + 2,4-D is a restricted use pesticide in California and requires enclosed system application (USDA/EPA/States, 1980) would alter this alternative's treatment cost. However, the degree of cost increase is considered minor, perhaps only 2-3% (USDA/EPA/States, 1980).

The relatively wide range in total per acre treatment costs ($14.47-$53.00) may be due in part to the lack of data concerning any additional mowings and/or hand cuttings necessary with alternatives. Additional equipment and labor costs would affect the cost differentials presented in Table 1.

Table 1. Comparative Acre Treatment Costs of Nitrofen and Selected Alternatives for Non-Cropland Areas

Herbicide	Formulation	Product Cost ($)	Product Application Rate Per Acre a/	Application Cost Per Acre Treatment b/ ($)	Total Per Acre Treatment Cost c/ ($)	Difference in Per Acre Treatment Costs Between Alternative and Nitrofen ($)
nitrofen	25 EC	13.86/gal.	2.50- 3.00 gals.	8.00	46.12	-
nitrofen	50 WP	3.97/lb.	10.00-12.00 lbs.	8.00	51.67	-
atrazine	80 WP	1.93/lb.	5.00-12.50 lbs.	8.00	24.89	-21.23 to -26.78
dicamba + 2,4-D d/	L	19.90/gal.	.13-.50 gal.	8.20	14.47	-31.65 to -37.20
diuron	80 W	3.60/lb.	5.00-20.00 lbs.	8.00	53.00	1.33 to 6.88
glyphosate e/	L	69.20/gal.	.50 gal.	8.00	42.60	-3.52 to -9.07

a/ Based on reported active ingredient application rates of USDA/EPA/States Nitrofen Assessment Team and dicamba + 2,4-D label rate.
b/ Application methods and, hence, costs are assumed to be identical ($8.00/acre) for non-restricted use pesticides. However, dicamba + 2,4-D is a restricted use pesticide in California and requires enclosed system application, which would alter treatment cost. The degree of cost increase is considered minor, possibly 2-3% (USDA/EPA/States, 1980).
c/ Product costs per acre treatment are based on the midpoint of application rates.
d/ Pre-mix of dicamba 1 lb. a.i./gal. and 2,4-D 3 lb. a.i./gal. (Farm Chemicals Handbook, 1980).
e/ Sold as an aqueous solution of isopropylamine salt of glyphosate and wetting agents (Farm Chemicals Handbook, 1980).

Sources: Monsanto® Company, 1980.
USDA/States/EPA, 1980.
Velsicol® Chemical Corporation, 1979.
Weed Control Manual, 1980.

The difference between total per acre treatment costs of selected alternatives and the nitrofen formulations ranges between \$31.65 and \$37.20 less for dicamba + 2,4-D to \$1.33 and \$6.88 more for diruon (Table 1). Based on the fact that the nitrofen formulation primarily used is 25EC (USDA/EPA/States, 1980), total treatment cost changes due to usage of the selected alternatives range from \$6.88 more to \$31.65 less per acre (Table 1).

Treatment costs presented in Table 1 were based on insufficient data. If nitrofen were no longer available for use on non-cropland areas, usage of alternative pesticides, such as atrazine or dicamba + 2,4-D or glyphosate, may result in decreased short and long run user expenditures. Usage of an alternative, such as diuron, may result in increased short and long run user expenditures.

Consumer/Market/Macroeconomic/Social/Community Impacts

If nitrofen becomes unavailable for use, no consumer, market, macroeconomic, or social/community impacts are expected.

LIMITATIONS OF THE ANALYSIS

1) There were no complete usage data available for nitrofen and selected alternatives.

2) There were no test data available on the comparative efficacy of nitrofen and alternative herbicides.

3) A complete listing of weeds controlled by all alternatives to nitrofen was unavailable.

4) It is unknown whether any additional mowings and/or hand cuttings would be necessary with the usage of alternatives.

5) It was assumed that the cost of pesticide application equipment and labor for non-restricted herbicides will equal \$8.00/acre while restricted use pesticide application costs will be 2-3% higher.

REFERENCES

California. 1979. California Department of Food and Agriculture. Annual Pesticide Use Report. Sacramento.

California. 1978. California Department of Food and Agriculture. Annual Pesticide Use Report. Sacramento.

California. 1977. California Department of Food and Agriculture. Annual Pesticide Use Report. Sacramento.

Farm Chemicals Handboook. 1980. Meister Publishing Company. Willoughby, Ohio.

Monsanto® Company. 1980. Product label for Roundup. EPA Reg. No. 524-308-AA.

U.S. Department of Agriculture/U.S. Environmental Protection Agency/States Assessment Team for Nitrofen. 1980. Draft Biological Assessment of Nitrofen. Washington, D.C.

U.S. Environmental Protection Agency. 1980. Benefit Analysis of Nitrofen. Office of Pesticide Programs. Benefits and Field Studies Division. Washington, D.C. July.

Velsicol® Chemical Corporation. 1979. Product label for Weedmaster®. EPA Reg. No. 876-203.

Weed Control Manual. 1980. Meister Publishing Co. Willoughby, Ohio.

ECONOMIC IMPACT ANALYSIS ~~ON~~ of nitrofen use
PINE SEEDLING NURSERIES

B. Ted Kuntz[1/]

The estimated economic impact of canceling ~~Tok~~ nitrofen uses on pine seedling nurseries was based on the following procedures and assumptions:

1. Pine seedling nurseries occurring in the states of Georgia, North Carolina, and South Carolina are included in the analysis. ~~Tok~~ Nitrofen is used one to two times in Georgia, 16 to 20 times in North Carolina, and 3 to 4 times in South Carolina per crop of pine seedlings.

2. Principle problem weeds controlled are ________________ ____.

3. The acres planted and acres treated with Tok were estimated by agricultural scientists working in the pine seedling-producing areas (table 1). Only the acres currently treated are included in the analysis.

4. The alternative weed-control ~~program was~~ programs were specified by agricultural scientists (table 1). ~~This~~ These alternative ~~program was~~ programs were assumed to be the best programs available if ~~Tok~~ nitrofen were canceled. Market availability and efficacy of the alternatives were considered in specifying the alternative programs.

1/ B. Ted Kuntz is an Agricultural Economist for the Economics and Statistics Service, Natural Resource Economics Division, U.S. Department of Agriculture, Corvallis, Oregon.

Table 1.--Current use and costs of ~~Tok~~ nitrofen and potential alternatives for weed management in pine seedling nurseries, Georgia, North Carolina, and South Carolina

State and alternative treatment	Acres: In area[a/]	Acres: Treated[b/]	Number of applications[a/]	Pound a.i.: Per acre[a/]	Pound a.i.: Total	Material cost per pound a.i. or labor cost per acre	Per acre treatment cost: Materials	Per acre treatment cost: Application[a/]	Per acre treatment cost: Total	Total cost	Change in costs using best alternative: Per Acre	Change in costs using best alternative: Total
						----Dollars----						
Georgia:												
~~Tok~~ Nitrofen......	300	50	1 to 2X	2.0	100 to 200	6.93[b/]	13.86 to 27.72	4.20 to 8.40	18.06 to 36.12	903 to 1,806		
Alternative program:												
~~Varsol~~ Petroleum distillate..........		50	1 to 2X	60.0[c/]	3,000 to 6,000 c/	1.25[b/]	75.00 to 150.00	4.20 to 8.40	79.20 to 158.40	3,960 to 7,920		
Addl. handwdng..		50	5-6 hrs	--	--	4.20[a/]	--	21.00 to 25.20	21.00 to 25.20	1,050 to 1,260		
Total.......	300	50	--						100.20 to 183.60	5,010 to 9,180	82.14 to 147.48	4,107 to 7,374
North Carolina:												
~~Tok~~ Nitrofen......	450	102	16 to 20X	1.0	1,632 to 2,040	6.93[b/]	110.88 to 138.60	67.20 to 84.00	178.08 to 222.60	18,164 to 22,705		
Alternative program:												
~~Varsol~~ Petroleum distillate..........		25	3 to 4X	60.0[c/]	4,500 to 6,000 c/	1.25[b/]	75.00 to 150.00	12.60 to 16.80	~~87.20~~ 87.60 to 166.80	~~2,180~~ 2,190 to 4,170		
~~Goal~~ Oxyfluorfen..........		102	3 to 4X	0.5	153 to 204	28.00[b/]	42.00 to 56.00	12.60 to 16.80	54.60 to 72.80	5,569 to 7,426		
Addl. handwdng..		102	10 hrs	--	--	4.20[a/]	--	42.00	42.00	4,284		
Total.......	450		--						~~117.97~~ 118.[illegible] to ~~155.69~~ 155.67 d/	~~12,033~~ 12,[illegible] to ~~15,880~~ 15,878	~~-60.11~~ -66.[illegible] to ~~-66.91~~ -66.93	~~-6,131~~ -6,122 to ~~-6,825~~ -6,827
South Carolina:												
~~Tok~~ Nitrofen......	200	50	1 to 3X	2.0	100 to 300	6.93[b/]	13.86 to 41.58	4.20 to 12.60	18.06 to 54.18	903 to 2,709		
Alternative program:												
~~Varsol~~ Petroleum distillate..........		50	1 to 2X	60.0[c/]	3,000 to 6,000 c/	1.25[b/]	75.00 to 150.00	4.20 to 8.40	79.20 to 158.40	3,960 to 7,920		
Addl. handwdng..		50	5 to 6 hrs	--	--	4.20[a/]	--	21.00 to 25.20	21.00 to 25.20	1,050 to 1,260		
Total.......	200	50	--	--	~~300 to 600~~	--			100.20 to 183.60	5,010 to 9,180	82.14 to 129.42	4,107 to 6,471
Total, 3 states.	950	202										~~2,103~~ 2,092 to ~~7,020~~ 7,018

a/ Walter A. Skroch.

b/ AGCHEMPRICE, 7-15-80.

c/ Gallon.

d/ Weighted average.

5. The herbicide bifenox, was not considered an alternative because it decomposes into ~~Tok~~ nitrofen after application.

6. It was assumed that no new alternatives will become available in the near term, that the prices for alternative herbicides will not change, and the alternative will be available in sufficient quantities. It was also assumed that sufficient labor will be available for hand weeding at prevailing market prices.

7. An estimated 10 percent reduction in harvested pine seedlings is assumed with the alternative treatment program. These lost seedlings are needed for reforestation purposes, so it was assumed that 11.1 percent more acres would be planted to replace the lost seedlings.

8. Value of the lost seedlings is assumed to be the cost of replacement seedlings. Thus, 11.1 percent of the production costs of the treated acres was assumed to be the value of lost production.

9. Partial budgeting techniques were used to estimate the economic impact of a ~~Tok~~ nitrofen cancellation.

Results

About 950 acres of pine seedlings are planted annually in the States of Georgia, North Carolina, and South Carolina. Average yield is 225,000 pine seedlings per acre. Valued at the approximate cost of production of $5,625 per acre, the total value of these pine seedlings is $5,343,750.

An estim ed 202 acres of pine seedlings are treated annually with ~~Tok~~ nitrogen in t. 3 states.

Georgia

An estim ed 50 acres of pine seedlings in Georgia are treated one or two tir s with 2 pounds a.i. of nitrogen ~~of Tok~~ per acre for a total of 100 to 200 pounds a.i. eac year (table 1). At the current price of $6.93 per pound (a.i.), he cost of nitrogen ~~Tok~~ is $13.86 plus $4.20 for application, or a total of 18.06 per acre per treatment. Total expenditures for nitrogen ~~Tok~~ use on pi seedlings in Georgia range from ~~are~~ $903 to $1,806.

The alte ative weed-control program includes one to two applications of Petroleum distillate ~~Varsc~~ and 5 to 6 hours of additional hand weeding. Total cost of the a ernative program is estimated to range from $5,010 ~~be $5,110~~ to $9,180, which is an increase i cost of $4,107 ~~$4,207~~ to $7,374 or about $82 ~~$84~~ to $147 per acre.

Use of th alternative ~~less effective~~ weed-control program is expected to res t in 10 percent decrease in harvested seedlings. These seedlings are eeded for reforestation purposes; therefore, the alternative treatm t program includes planting 11.1 percent more acres of seedlings to ovide the same number of seedlings currently produced on the nitrogen ~~Tok~~-tre ted acres. In Georgia, an additional 5.6 acres will be planted to replace the l t seedlings. At the average production cost of $5,625 per acre, thi represents a $31,500 loss.

Total lo es in Georgia, including increased treatment costs and cost of repla ment seedlings, are estimated to range from $35,607 ~~be $35,707~~ to $38,374 the first yea without ~~Tok.~~ nitrogen.

North Carolina

An estimated 102 acres of pine seedlings in North Carolina are treated 16 to 20 times with one pound a.i. of nitrofen ~~of Tok~~ per acre for a total of 1,632 to 2,040 a.i. pounds annually (table 1). Per treatment cost of ~~Tok~~ nitrofen is $6.93 per acre plus $4.20 for application, or $11.13 per acre per treatment. Total expenditures for nitrofen ~~Tok~~ use on pine seedlings in North Carolina range from ~~are~~ $18,164 to $22,705.

The alternative weed-control program includes 3 to 4 applications of petroleum distillate ~~Varsol~~, 3 to 4 applications of the herbicide oxyfluorfen (only 50 · 25 of 102 nitrofen treated acre ~~Goal~~, and 10 hours of additional hand weeding. Total cost of the alternative program is estimated to range from $12,042 to $15,878 ~~be $12,033 to $15,880~~, a decrease in cost ranging from $6,122 to $6,827 ~~of $6,131 to $6,825~~ or about $60 to $67 per acre.

Use of the alternative ~~less effective~~ weed-control program is expected to result in a 10 percent decrease in harvested seedlings. These seedlings are needed for reforestation purposes; therefore, the alternative treatment program includes planting 11.1 percent more acres of seedlings to provide the same number of seedlings currently produced on the nitrofen ~~Tok~~-treated acres. In North Carolina, 11.3 acres will be planted to replace the lost seedlings. At the average production cost of $5,625 per acre, this represents a $63,563 loss.

Total losses in North Carolina, including increased treatment costs and cost of replacement seedlings, are estimated to range from $57,441 to $56, ~~be $57,432 to $56,738~~ the first year without ~~Tok.~~ nitrofen.

South Carolina

An estimated 50 acres of pine seedlings in South Carolina are treated one to three times with two pounds a.i. of nitrogen ~~of Tok~~ per acre for a total of 100 to 300 pounds a.i. annually (table 1). Per treatment cost of ~~Tok~~ nitrogen is $13.86 per acre plus $4.20 for application, or $18.06 per acre per treatment. Total expenditures for ~~Tok~~ nitrogen use on pine seedlings in South Carolina are $903 to $2,709.

The alternative weed-control program includes one or two applications of ~~Varsol~~ petroleum distillate and 5 to 6 hours of additional hand weeding. Total cost of the alternative program is estimated to range from ~~be~~ $5,010 to $9,180, an increase in cost of $4,107 to $6,471, or about $82 to $129 per acre.

Use of the alternative ~~less effective~~ weed-control program is expected to result in a 10 percent decrease in harvested seedlings. These seedlings are needed for reforestation purposes; therefore, the alternative treatment program includes planting 11.1 percent more acres of seedlings to provide the same number of seedlings currently produced on the ~~Tok~~ nitrogen-treated acres. In South Carolina, 5.6 acres will be planted to replace the lost seedlings. At the average production cost of $5,625 per acre, this represents a $31,500 loss.

Total losses in South Carolina, including increased treatment costs and cost of replacement seedlings, are estimated to be $35,607 to $37,971 the first year without ~~Tok~~. nitrogen.

Summary

An estimated 202 acres of pine seedlings are annually treated with 1,832 to 2,540 pounds a.i. of nitrogen ~~of Tok~~ for weed control ~~annually~~ in Georgia, North Carolina, and South Carolina. Use of the alternative ~~less effective~~ weed-control programs ~~is~~ are expected to result in total grower losses ranging from $128,6 ~~losses of $128,746~~ to $133,581 ~~$133,583~~ the first year without nitrogen. ~~Tok.~~ Increased treatment costs are estimated to range from $2,092 to $7,018 and the ~~be $2,183 to $7,020 and~~ cost of replacement seedlings is estimated to be $126,563.

SUMMARY PRELIMINARY BENEFIT ANALYSIS:
USE OF NITROFEN FOR SUGARBEETS

A. USE: Nitrofen (Tok® E-25) is used to control weeds for sugarbeets in the Imperial Valley region of California and Yuma County, Arizona.

B. MAJOR PESTS CONTROLLED: Winter annual broadleaf weeds are primary nitrofen targets, particularly wild beets (Beta maritima).

C. ALTERNATIVES:

Major registered alternatives:

Eptam	chloroprophal	desmedipham
cycloate	ethofumasate	phennedipham

Non-chemical alternatives: Cultivation and hand weeding.

Efficacy of alternatives: Each chemical alternative controls a varying spectrum of weeds, but none are as broad as that controlled by nitrofen.

Comparative performance: The alternative program of cycloate, chloropropham and desmedipham/phenmedipham requires one additional cultivation and 7 additional hours of hand weeding per acre, and results in a 2 percent yield reduction.

Comparative Costs:

Nitrofen Program Cost for Impacted Acres	Alternative Program Cost for Impacted Acres	Cost Difference for Impacted Acres
$745,740	$1,513,275	$767,535

The nitrofen program includes nitrofen in sequence with chloropropham and 6 cultivations. The alternative program consists of cycloate, chloropropham, desmedipham/phenmedipham, 7 cultivations and 7 hours of hand weeding. Both programs include chemical application costs.

D. EXTENT OF USE: Approximately 45% of sugarbeet acreage in the Imperial Valley is treated.

Total Planted acres in Imperial Valley 1077-79	Total acres treated in Imperial Valley 1977-79	Total Pounds AI of Nitrofen
16,670	7,500	30,000

Only 6,000 acres receive the cycloate application in the nitrofen program.

E. ECONOMIC IMPACTS:

User: An impacted sugarbeet grower would incur an additional production cost of $98.41 to $118.05 per acre. The total cost impact for all 7,500 acres would be an increase of $767,535.

The reduction in yield for the total impacted acreage is estimated to be about 3,600 tons per year. This is less than 1% of the total production in the Imperial Valley and only about 0.01% of total U.S. production.

The short term loss in net farm income per farm in the Imperial Valley is estimated to be $9,267. The total farmer's net income would be reduced by $864,771.

The $112 to $132 decrease in farm income per acre may cause sugarbeet growers to shift acreage to alternative crops. The following crops used in rotation are possible substitutes: alfalfa, carrots, cotton, garlic, lettuce, melons and onions.

Consumer: Since the quantity and quality losses are negligible compared to the total U.S. market, there would not appear to be any significant impact on prices or consumption.

Macroeconomic: No significant impact is expected.

F. SOCIAL AND COMMUNITY IMPACTS: Increased employment for farm workers in short term. In longer term crop shifts may impact sugarbeet processor.

G. LIMITATIONS OF ANALYSIS: Lack of experimental data; yield losses and other biological data were based on professional judgment. Limited economic information was available. Short term farm output prices were assumed constant and labor supplies were assumed readily available. It is uncertain how many acres will shift to alternative crops and comparative returns for alternative uses of farm resources are unavailable.

H. PRINCIPAL ANALYST AND DATE:

Robert Esworthy
Economic Analysis Branch
Benefits and Field Studies Division
Office of Pesticide Programs
U.S. Environmental Protection Agency

January 1981

Preliminary Benefit Analysis of Nitrofen Use on Sugarbeets In the Imperial Valley, California

Current Use Analysis

EPA Registrations of Nitrofen and Alternatives

Nitrofen (Tok®) is registered as a Special Local Need (SLN) for sugarbeets in the Imperial Valley region of California. Winter annual broadleaf weeds are primary nitrofen targets, wild beets (Beta maritima) being the most important due to a lack of alternative controls. As well as competing with sugarbeet growth, the wild beet poses another problem in that it is a host for diseases common to domestic beets. These include powdery mildew, caused by the fungus Erysiphe polygoni, and two viral diseases; curly top and beet yellow (Breithaupt, 1980). An emulsifiable concentrate formulation of nitrofen (Tok EC-25) is applied only once to sugarbeet acreage at a rate of 4 pounds active ingredient per acre (EPA, 1980). Nitrofen is applied as a preemergent and is followed by a postemergent application of chloropropham (USDA/EPA/States, 1980).

Eptam, cycloate, chloropropham, desmedipham, ethofumasate, and phenmedipham are registered weed controls on sugarbeets (EPA, 1980; EPA microfiche, 1980). Each alternative controls a varying spectrum of weeds, but none are as broad as the spectrum controlled by nitrofen.

Use of Nitrofen and Alternatives

Approximately 45 percent (7,5000 acres) of the annual average 16,670 acres of sugarbeets planted in the Imperial Valley during 1977-1979 were treated with nitrofen. Table 1 presents current use of nitrofen and the alternative program if nitrofen was not available. The alternative control program on a per acre basis consists of a preplant incorporation of cycloate (4.0 lbs AI), a postemergence spray of chloropropham (5.0 lbs. AI) and a 10 inch postemergent band spray of a combined desmedipham/phenmedipham formulation (USDA/EPA/States, 1980). This program requires one additional cultivation and an additional 7 hours of hand weeding per acre.

Economic Impact Analysis

Farm Impacts

Comparative weed control costs of nitrofen and the alternative program are presented in Table 2. An impacted sugarbeet grower would incur an additional cost of \$98.41 to \$118.05 per acre if nitrofen were no longer available. Since the average Imperial Valley sugarbeet farm grows 80 acres (USDA/EPA/States 1980), the increased cost per farm with all acres impacted would be \$8,187. The total cost impact for all 7,500 acres would be an increase of \$767,535.

Table 1. Current Use of Nitrofen and the Alternative Control Program for Sugarbeets in the Imperial Valley of California[a/]

Weed Control Program	Timing of Application	Total Treated Acres	Application Rate/Acre (lbs. AI)	Total Pounds AI	Number of Applications	Number of Cultivations [b/]	Hand Weeding [b/] (hours)	Percent Yield Reduction	Change in Crop Quality
Nitrofen Sequence									
Nitrofen	preemergent	7,500	4.0	30,000	1	4-6	[c/]		
Chloropropham	postemergent	6,000	4.0	24,000	1				
Alternative Sequence									
Cycloate	preplant incorporated	7,500	4.0	30,000	1				
Chloropropham	post emergent	7,500	5.0	37,500	1	5-7	7 [c/]	2	negligible
Desmedipham/ Phenmedipham	postemergent 10 inch band	7,500	0.5+0.5	3,750+3,750	1				

a/ Based on average data for 1977-79.
b/ For the entire treatment sequence.
c/ Little general hand weeding is done because of the Sugar Act wage guidelines. Hand weeding limited to rogueing out large escape weeds that are not well controlled by existing herbicides. Without nitrofen, an additional 7 hours of hand weeding is presumed necessary (USDA/EPA/States, 1980).

Source: USDA/EPA/States, 1980.

Table 2. Comparative Weed Control Costs for Nitrofen and the Alternative Program in the Imperial Valley of California

Weed Control Program	Treated Acres	Herbicide Cost a/ ($/acre)	Application Cost b/ ($/acre)	Cultivation Cost c/ ($/acre)	Additional Hand Labor Cost d/ ($/acre)	Weed Control Cost/Acre ($/acre)	Total Weed Control Cost ($)
Nitrofen Sequence							
Nitrofen	7,500	27.72	8.00				
Chloropropham	6,000	11.64	8.00				
Cultivation	7,500			48.00			
Total		27.72-39.36	8.00-16.00	48.00		83.72-103.36	745,740
Alternative Sequence							
Cycloate	7,500	25.56	18.00				
Chloropropham	7,500	14.55	8.00				
Desmedipham/ Phenmedipham	7,500	34.66	8.00				
Cultivation	7,500			56.00			
Hand Weeding	7,500				37.00		
Total		74.77	34.00	56.00	37.00	201.77	1,513,275
Net Increase		35.41-47.05	18.00-26.00	8.00	37.00	98.41-118.05	767,535

a/ Price/lb. AI: nitrofen, $6.93; chloropropham, $2.91; cycloate, $6.39; desmedipham, $38.54; phenmedipham, $30.77.
b/ Rowe, G., and B. Albertson, 1980.
c/ Cost is $8.00/cultivation. Assumes 6 cultivations for the nitrofen sequence and 7 cultivations for the alternative sequence.
d/ Number of hours of hand labor with nitrofen is unknown at this time. It is estimated that 7 additional hours at $37.00/acre would be required without nitrofen.

Source: USDA/EPA/States, 1980; Rowe G. and Albertson, 1980.

Although the quality of the crop is not expected to change with the alternative control, a 2 percent yield reduction is anticipated (USDA/EPA/States, 1980). The reduction in yield for the total impacted acreage is estimated to be about 3,600 tons per year. This amounts to less than 1 percent of the total production in the Imperial Valley and only about 0.01 percent of total U.S. production (Table 3). Based on 1977-79 average sugarbeet price of $27.01, the lost value of production is estimated to be $97,236.

Due to increased production costs and decreased value of production, total farmers' net income in the Imperial Valley would be reduced by $864,771. Since an average farm is 80 acres, the reduction in net farm income would be $9,267 per farm with all acres impacted.

Since the use of the alternative control decreases net farm income by about $112 to $132 per acre, growers might shift acreage to alternative crops. The following crops used in rotation are possible substitutes: cotton, alfalfa, lettuce, melons, carrots, garlic and onions. It is not known what proportion of acres will shift to the alternative crops.

Consumer Impacts

The maximum loss of production in the Imperial Valley is a very small proportion (0.01%) of total U.S. sugarbeet production. Since the quantity and quality losses are negligible, there would not appear to be any significant impact on prices or consumption.

Table 3. Average (1977-79) Planted Acres, Harvested Acres, Yield, Production and Value of Production for Sugarbeets

	Planted Acres (1000)	Harvested Acres (1000)	Yield Per Harvested Acre (tons)	Total Production (1000 tons)	Average Price/Ton a/ ($)	Total Value of Production ($1000)
Nitrofen treated acres (Imperial Valley)	7.5	7.2	25.0	180.0	27.01	4,861.80
Total Imperial Valley	16.67	16.0	25.0	400.1	27.01	10,806.70
Total U.S.	1,250.1	1,201.7	20.2	24,274.3	27.01	655,643.84

a/ The $27.01 is 1977-79 average U.S. price.

Sources: USDA, Crop Production 1979 Annual Summary, 1980.
USDA, Agriculture Prices 1979 Annual Summary, 1980.

Social Community Impacts

Data limitations make it difficult to assess the social and community impacts of cancelling nitrofen use on sugarbeets. The additional cultivation and hand weeding required with the alternative control program will lead to increase employment for farm workers. Crop shifts may cause some social and community impacts (e.g. sugarbeet processor, new investment in farm equipment). Any social/community impacts would become less significant over time.

Macroeconomic Impacts

The cancellation of nitrofen use on sugarbeets is not expected to have significant impacts.

Limitations of Analysis

1. It is uncertain if the nonavailability of nitrofen will force sugarbeet growers into producing other crops.

2. Farm income changes assume no change in the price of sugarbeets or factors of production (e.g. hand weeding labor) if nitrofen is not available for use.

References

Breithaupt, Barbara, Plant Physiologist PSB, OPP, BFSD, U.S. Environmental Protection Agency. Personal communication, 1980.

Rowe, Gordon and Barbara Albertson, draft inputs to TOK (nitrofen) Cultural Practices for Crops - Economic Impacts, University of California, Berkeley, Berkeley, California, July 14, 1980.

U.S. Department of Agriculture. Crop Production 1979 Annual Summary - Acreage, Yield, Production. ESCS Crop Reporting Board, CRPR 2-1 (80), Washington, D.C. January 1980.

U.S. Department of Agriculture. Agriculture Prices Annual Summary 1979, ESCS Crop Reporting Board, Pr 1-3(80). Washington, D.C.

U.S. Department of Agriculture, U.S. Environmental Protection Agency and States Assessment Team for Nitrofen. Draft Biological Assessment of Nitrofen, Washington, D.C., 1980.

U.S. Environental Protection Agency. Benefit Analysis of Nitrofen. OPP, BFSD, Washington, D.C., July 1980.

U.S. Environmental Protection Agency, Office of Pesticide Programs, Pesticide Product Information on Microfiche. Chemical/Site/Pest Microfichc File 1979.